THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

---

ART. XXII.—*A brief Notice of the Life, Researches, and Discoveries of Friedrich Wilhelm Bessel;* by Sir J. F. W. HERSCHEL.*

FRIEDRICH WILHELM BESSEL was born at Minden, July 22, 1784. His father held an office of local administration under the Prussian government (Justiz-Rath). His mother was the daughter of a clergyman, Schrader by name, at Rehme. Being one of a family of nine children, his education, though not neglected, was in no respect calculated to fit him for his future distinguished career. It is said that he showed an early disinclination for the elements of classical literature; most probably from the repulsive form in which they are usually administered to children. Be that as it may, he manifested a decided preference for, and early expertness in, arithmetic; which his father perceiving, placed him, at the age of fifteen, as an apprenticed clerk in a considerable commercial house at Bremen, (Kuhlenkamp and Sons.)

A boyish story is told of his grinding a glass with emery in a saucer, and remarking, with delight, that it in some degree concentrated the rays of the sun; perhaps in rude imitation of some process he had read of, or been told. A more decidedly characteristic anecdote is recorded, of his having in his thirteenth year, remarked, while comparing the constellations in the heavens with their representation on a planisphere, that $\varepsilon$ *Lyræ*, marked as one

* Extracted from the Annual Report of the Royal Astronomical Society, London, 1847.

star in the chart, consists of two, which his eye was sharp enough to distinguish separately, though at so small an interval as $3' 32''$. This must certainly be regarded as an uncommon proof, not only of acute vision, but of close and careful attention in a boy so young, and as manifesting that capacity for becoming earnestly interested in a subject to which the natural faculties of the mind are best adapted, which is all that can be understood by an early bent of genius.

Earnest attention and zealous occupation with the business before him, of whatever nature, seems, however, to have been a primary feature of his character. In his new situation he speedily mastered, not merely the routine of his own subordinate position, but gained a thorough insight into the general nature of the business of his firm; and, entering into all his duties with uncommon diligence, rapidly acquired the approbation and confidence of his employers; leading him to hope that the more responsible situation of supercargo, in a voyage to the French and Spanish colonies and China, might be offered to him. To prepare himself for this great object of his ambition, he commenced the study of the French and Spanish languages, and of navigation, taking for his guide in that branch, the old work of Hamilton Moore. The rules and processes of nautical reckoning delivered in that work as precepts, without their theoretical grounds, induced him to seek the latter elsewhere. He procured a popular treatise on astronomy. This directed him in the right course; and proceeding from book to book, and mastering their difficulties as best he might, he found at length an effectual bar to further progress in his entire unacquaintance with mathematics. He immediately entered on a course of mathematical reading, and now we hear no more of commercial projects, or of the voyage he had so ardently desired. Every leisure hour (and they were chiefly in the night) was devoted to astronomical and mathematical reading. Practice was also combined with theory. By the aid of a rude wooden sextant, which he got constructed by a carpenter, and a common clock, he began to make observations for time; and great was his joy when the occultation of a considerable star by the moon, which he was fortunate enough to observe, gave him the longitude of Bremen with considerable approximation. The rapidity of his progress from this time was truly astonishing. Trains of original research and learned inquiry opened out before him at an age when the generality of students, under the most favorable circumstances, hardly advance beyond the elements of science. Already in his twentieth year, he had executed the reduction of Harriott's and Torporley's observations of the comet of 1607, which has become so celebrated by the great discovery of its periodical return by Halley. These observations had been but recently rescued from oblivion by Baron Zach, in

his search among Harriott's papers, in the possession of the Earl of Egremont; and, being the first observations of this remarkable body made with any kind of instrumental aid, their reduction was an object of undeniable importance. This task Bessel executed in so masterly a manner, as to call forth the warmest eulogies from Olbers to whom he communicated them, and to excite the strongest desire in him to secure for astronomy one whose future eminence in that science he clearly foresaw, and in no sparing or measured terms predicted. This performance, his first public work, appeared in Zach's *Monathliche Correspondenz*, and was immediately followed by a theoretical memoir, of great importance, "On the calculation of the true anomaly in orbits nearly parabolic." So expert had he become in cometic calculations, that Olbers, having placed in his hands, on the night of the 1st of November, 1805, four observations of the comet of that year, he returned them to him the next morning, with the elements, whose calculation had occupied him only four hours.

His seven years' engagement with Messrs. Kuhlenkamp was now terminated; but, instead of entering on the mercantile world on his own account, we find him placed forthwith, at the recommendation of Olbers, as assistant to Schröter, at Lilienthal, and successor to Harding. Astronomy thus became his profession; he gave himself wholly to it, with an energy and success which very speedily placed him in the first rank of its cultivators.

The instruments of Schröter were better adapted for physical examination than for precise astronomical determinations. Among the more especial objects to which his attention, *as an observer*, was there directed, may be mentioned a series of micrometrical measures of the distances of the sixth, or Huygenian, satellite of *Saturn* from the ring, made with a Newtonian reflector by the aid of the projection micrometer, with a view to the better determination of the mass of *Saturn* and of its ring, by means of the perturbations caused thereby in the satellite's motions. This work, so begun, was never subsequently lost sight of. It forms the subject of several elaborate memoirs, the first of which appeared in the *Königsberger Archiv fur Naturwissenschaften*, No. 2, in which all the observed conjunctions and oppositions of the satellite, and all the recorded disappearances of the ring, are subjected to a rigorous and systematic calculation; the position of the ring itself normally determined, together with elements of the orbit of the satellite in question, and even the perturbations of its motion by the attraction of the ring and by the sun are made objects of minute inquiry. The subject was resumed as observations accumulated, especially those made with the celebrated heliometer of Fraunhofer, in three admirable papers, Nos. 193–5, No. 214, and No. 242 of the *Astronomische Nachrichten*. At Lilienthal, also, were made his observations of the comet of

1807, the investigation of whose elements, taking into account its perturbations, was published in 1810, and gained him the prize founded by Lalande, from the Institute of Paris.

In 1810, he removed from Lilienthal to Königsberg, being appointed to the direction of the observatory about to be established there by the King of Prussia, and whose construction and provision with instruments he was called on to superintend. This observatory will ever remain a monument to his glory, no less than to the munificence of the sovereign, who, amidst the alarms of war and the desolation of his country, still mindful of science, ordained its institution. The building was completed and the observations commenced in 1813, from which time to the conclusion of his life, an uninterrupted series of the most valuable and important observations continued to emanate from it. Soon after his appointment to this situation, (in which, besides the duties of an observer, he had also those of a professor in Königsberg University to fulfill, by giving a course of lectures on astronomy and mathematics,) he married the daughter of Professor Hagen, by whom he had one son and two daughters. The death of the former, however, in 1841, a fine and talented young man, who already, at an early age, gave the promise of eminent distinction in astronomy, proved to him a most severe trial; which, however, he bore with resignation, taking refuge from his grief in increased exertions. These brought on, or at least exasperated, an internal complaint, arising, in the opinion of his physicians, afterwards verified on actual examination, from the abnormal and fungous growth of some intestinal organ, under which, after much protracted suffering, he at length succumbed, and expired on the 7th of March, 1846, in the 62d year of his age.

An extensive and minute account of the labors of this illustrious astronomer cannot be expected in a notice of this nature: all that can be done is to touch, and that briefly, on some of the principal among them.

Of his early and successful devotion to the improvement of our knowledge of comets, something has been already said. This ever continued a favorite subject with him; and in 1835, he had the great satisfaction to observe, with all the means which modern instruments afford, the wonderful phenomena of Halley's comet, the reductions of whose early observations (in preparation for this return of it to its perihelion) had signalized his first entry into his astronomical career. His observations of its physical appearance previous to its perihelion passage, and especially of the apparent oscillations to and fro of those singular jets of light from its head, which created so much astonishment among European observers, from day to day, and even from hour to hour, led him to conclude the inherence in the cometary matter of a polar or magnetic energy, and even to make (*Astronomische Nachrich-*

*ten*, No. 310) the effect produced on a comet's orbit by the reaction of the matter of these jets, so projected forth from the nucleus into space, a subject of mathematical calculation. And it may not be irrelevant here to notice that other phenomena, of a totally different nature, exhibited by the same comet subsequent to its perihelion passage, as observed in the southern hemisphere, appear to authorize conclusions, which, though not precisely identical with those of Bessel, have yet so much in common with them, that the assumption of repulsive forces as a means of accounting for cometary phenomena, must henceforward take its place among hypotheses which cannot be lightly rejected, but must come to be tested by the combined aid of rigorous mathematical deduction and increased refinement of observation.

In a note appended to one of the numbers of the *Astronomische Nachrichten* (No. 175), the following remarkable expression of Schumacher occurs:—"It may almost be said that one exact and able calculator is capable of doing better service to astronomical science than two new observatories." It was in the capacity of such a calculator (taking the word in that enlarged and eminent sense in which the writer doubtless understood it,—a calculator thoroughly master of every resource of theory, and capable of bringing them all to bear on the subject of discussion) that Bessel undertook and completed, while yet young as an astronomer, his great work, the *Fundamenta Astronomiæ*, a work which it is difficult for any astronomer, and least of all an English one, to speak of in measured terms. It affords the first example of the complete and thorough reduction of a great series of observations, grounded, in the first instance, on a rigorous investigation, from the observations themselves, of all the instrumental errors, and carried out on a uniform plan, neglecting no minutiæ which a refined analysis and a perfect system of computation could afford, and resulting in a model catalogue, such as (without disparagement to the far more extensive catalogue of Piazzi, published four years antecedently) the world had not before imagined. As Englishmen, we cannot but be proud to have furnished from our national observatory, in the twelve years' work of a single British astronomer, that "one entire and perfect" mass of precious material, from which has been sculptured forth in so masterly a manner, and in all its classical proportions, the fair form of modern sidereal astronomy. Independent of the deduction of the places of the stars, of the instrumental reductions, and of the local data, the disquisitions which this work contains on the several uranographical corrections are, and ever must remain, models of delicate and powerful research, monographs of their respective subjects, embodying in a succinct and perspicuous point of view, so far as their complexity will admit, the totality of our knowledge of their theory brought into the most practical forms for applica-

tion. In the reduction of these observations, however, his final improvement, which does away altogether with the necessity of using special tables for the several uranographical corrections, and for individual stars, and renders it practicable, by the calculation of a system of constants for each star, and an annual table common to all the stars, to provide for the reduction of all meridional observations, was not yet adopted. That capital step, which has so infinitely facilitated all subsequent reductions, was not made till somewhat later, and had nearly been anticipated by Mr. Baily, who, on his part, and independently, had been occupied about the same time on a similar simplification.* In furtherance of the important object of facilitating the reduction of observations of the planets, as well as of the fixed stars, on a uniform system, he prepared and published, in 1830, his *Tabulæ Regiomontanæ*, a work of the greatest utility and influence on the practice of astronomers in this respect.

The principal instruments at first supplied to the Königsberg Observatory were two, a transit by Dollond, and a meridian circle by Cary. This last instrument, though not itself of a very high order of excellence, may be considered as having been rendered so by the masterly and elaborate investigation of its errors of division which Bessel bestowed upon it. The complete investigation of instrumental error was a subject on which he was at every period remarkably scrupulous, and not without reason, as the dreadful consequences which have followed its neglect in more than one instance clearly demonstrate. In *his* opinion, the reputation of no artist, however distinguished, could be held to dispense with the most careful and searching scrutiny into the errors of his workmanship; or, with the most refined application, both of experience and theory, into the amount and laws of its flexure, whether of the telescope or limb, by its own weight in different positions. In fact, no astronomer has ever gone deeper into the theory of instruments, or exemplified that theory by more elaborate experimental inquiries. The finishing hand was put to a most remarkable memoir on the effects of flexure, but a very short time previous to his death, which has only just seen the light (see *Astronomische Nachrichten*, No. 577, *et seq.*), its publication having been directed in his will.

The improvement of Carlini's tables of the sun was the object and result of the first five years' observations with Cary's circle and Dollond's transit; though other objects of interest were not neglected, especially that of an exact determination of the places of those stars in which large proper motions had been remarked. But when in the year 1820, the circle of Cary was

* See the Memoir of Mr. Baily, *Mem. Astron. Soc.*, vol. xv, p. 324, where, in line 7, for "*precession*" read *nutation*.

replaced by the larger and more accurate meridian circle of Reichenbach, a wider field of inquiry was opened out, and a task undertaken and completed of which astronomy is only now beginning to reap the fruits. This was no less than a determination of the places of all the stars, down to the ninth magnitude, in a zone of the heavens extending from 15° south to 45° north declination. Previous to entering upon this great work, however, the new instrument was subjected to a more severe and rigid scrutiny into the divisions of its circle, and the accurate adaptation of its parts (by the aid of a microscopical apparatus contrived and executed by Pistor), than that which its predecessor had undergone. It sustained the ordeal to admiration. The zone observations were commenced on the 19th of August, 1821, and completed on the 21st of January, 1833, in 536 zones, comprehending upwards of 75,000 observations. The arrangement of the work, as printed in the Königsberg observations, is in the highest degree convenient for reference. Every zone is accompanied by a small table, by means of which the reduction of any one of the observed objects to a fixed epoch may be performed at once, and in the shortest possible time; so that the observations themselves, by the aid of an index to the zones, have nearly all the advantage of a catalogue, and that of a very high degree of precision. Their actual reduction and arrangement as a catalogue was commenced in 1830 by Professor Weisse; but the promised work has not, we believe, yet appeared. Bessel was assisted in the observation of these zones by M. Argelander, who, since his removal to the direction of the observatory at Bonn, has continued them from the 45th to the 80th degree of north declination, the observations being very recently published in the first volume of the transactions of the Bonn Observatory, in 204 zones. It will be a matter of no small interest, when the elements of the new planets which have so recently been added to our list shall have become sufficiently known to admit of a retrospective ephemeris being calculated, to search the Königsberg zones for missing stars lying in their paths, and corresponding to former places of them. The detection of such will be of inestimable value in the correction of their elements and the theory of their perturbations.

Future astronomers will reap the rewards of this laborious work; but there was one subject of astronomical research, of a practical nature, which Bessel was destined to commence and carry out to its completion, terminating in a discovery of first-rate importance, in the determination, beyond the reach of reasonable doubt or cavil, of the parallax of a fixed star. The star, 61 *Cygni*, pitched upon for his attack upon this difficult question, which had so long bid defiance to the attemps of astronomers, and which seemed destined constantly to afford fresh

proofs of the imperfections of our instruments and the inadequacy of our methods, was one which combined, with distinct grounds of *à priori* probability in favor of its proximity to our system, peculiar advantages for the application of the mode of observation contemplated. The proper motion is remarkably large,—the greatest, with one exception, yet observed. This of itself affords some presumption of proximity. Another, less equivocal, is found in the fact, that it is demonstrably a binary double star, whose orbitual motion is remarkably rapid when compared with the apparent angular distance of its individuals, indicating a large angular dimension of the orbit mutually described about each other as seen from the earth. As regards its adaptation for micrometric observation, two minute stars, at the respective distances of 8′ and 12′ from the middle point of the pair, situated with respect to that point in positions differing by very nearly a right angle, permit no parallactic movement to take place without effecting a change of apparent distance from one or other of them; so that the maximum rapidity of change with respect to one shall correspond to the minimum and near evanescence of such change with respect to the other, a very important circumstantial character of the *reality* of any observed movement supposed to arise from parallax.

The only obstacle in the way of the detection of any minute parallactic motion, by means of these stars, consisted in the difficulty of measuring distances so large as 8′ or 12′ to the precision of a very small fraction of a second. Thanks to the perfect workmanship of the Munich opticians, this precision was rendered attainable by the heliometer constructed for the Königsberg Observatory, and there erected in 1829. The observations in question were made in the years 1837–1840; and their result as is well known, has satisfied every astronomer of the reality of the parallax attributed by Bessel to this star, and of the near approximation to its true amount.

The discussion of these observations involved considerations of very great delicacy, chiefly turning on the effect of temperature on the focal distances and metallic mounting of the lenses, as well as on an infinity of minute considerations as to the effects of refraction, &c., and of instrumental errors on the measures of angles of such magnitude in various positions with respect to the vertical. Every thing of this nature has been made the subject of minute and careful inquiry in four very elaborate papers forming part of the first volume of a series of essays (*Astronomische Untersuchungen*), of which we shall have further occasion to speak. The first of these enters in its fullest extent into the general theory and formulæ of an equatorially mounted heliometer. The second is devoted to a special application of this theory to the Königsberg instrument. Among the remarkable

features of this second memoir, deserves to be noticed a happy application of the general resolution, by continued fractions, of an equation of finite differences of the second order, to the expression of the course of a ray refracted through any combination of spherical surfaces. The third of these memoirs relates to the elimination of the influence of refraction; and the fourth to that of the several effects of precession, nutation, and aberration, from measures so taken, and from micrometric measures generally.

The exceeding precision of micrometric measurement of which the heliometer proved capable, was also brought to bear upon other objects, such as the measurement of distances of the Huyghenian satellite of *Saturn* from the ring, and those of *Jupiter* from the limb of the planet, with a view to the more perfect determination of the masses of these planets. The results of the latter observations, as compared with their theory, and the improved tables of the motions of the satellites themselves, concluded from the whole inquiry, are to be found in the Ninth Essay, Vol. II. of the *Astronomische Untersuchungen*, already referred to.

In the year 1824, in a paper communicated to Schumacher's *Astronomische Nachrichten*, No. 49, Bessel recalled the attention of astronomers to the great and peculiar advantages in the determination of latitudes, and of the declinations of such stars as pass near the zenith, offered by a mode of observation whose first idea seems to have been due to the celebrated Römer, viz. by the use of a transit instrument at right angles to the meridian, and therefore describing the prime-vertical. By the use of this method, the differences of declination of two stars passing near the zenith of any given places, or the change of declination of one and the same star at different times, comes to be measured upon a vastly increased scale by the interval of its two transits over the vertical, expressed in time. It is therefore independent of the errors of division of any circle, and, as Bessel has also shewn, of a variety of other influential causes of error, and is especially adapted for those inquiries in which the zenith sector has been usually employed. A large instrument constructed upon this principle has been since erected in the Imperial Observatory at Pulkowa, with the express object of affording normal results as to the constants of aberration, nutation, &c., and the investigation of parallax; and from the terms in which the illustrious astronomer at the head of that establishment speaks of its performance, the views of M. Bessel in recommending it for general adoption appear to be fully borne out.

Intent on fully providing the observatory under his direction with the most perfect instruments which art can execute, Bessel obtained permission to order for that institution a new and improved meridian circle from the Brothers Repsold, of Hamburg,

with peculiar adaptations, devised by himself, for facilitating the handling, setting, and reading of the circle. On the reception of this instrument, which was erected in the observatory about the end of 1841, a mode of determining the nadir point proposed by Bohnenberger, by reflexion of the wires of the instrument itself in mercury, by which the instrument is made its own vertical collimator, was adopted and brought into constant use; a full account of which, and of the extreme precision so attained, will be found in Nos. 480 and 481 of the *Astronomische Nachrichten*. The possession of this admirable instrument enabled him to resume, with every advantage he could desire, an inquiry of the greatest importance, but at the same time of the utmost delicacy, which had long engaged his attention. The first suspicion of a want of perfect uniformity in the proper motions of certain fixed stars, among which *Sirius* and *Procyon* may be especially particularized, occurred to Bessel in 1834. Pond appears also, at an earlier period, to have become impressed with the same idea. The observations of declination made at Königsberg, previous to the erection of the Repsold circle (see *Astron. Nachr.* 422), had tended greatly to confirm this suspicion; but it was not until a series of observations of considerable extent had been made with the new circle, that Bessel thought himself authorized to announce it as a positive astronomical fact, no longer to be confounded with possible error of observation and reduction, but as a thing to be accounted for by some distinct physical cause. On the nature of this cause he even hazarded a speculation, doubtless a very bold one, viz. that *Sirius* and *Procyon*, in which the observed deviation from uniformity is regarded by him as fully established, are really double stars, one of the individuals only, however, being luminous; and that the variability in question arises from their relative orbitual motion about their common centre of gravity. Time only, and assiduous observation, can elucidate this curious subject.

Though very far from having exhausted the catalogue of Bessel's purely astronomical discoveries and researches, the limits of this notice require us now to pass to the mention of his highly important investigations on subjects connected more immediately with our own globe, viz. geodesical measurements, the determination of standards of weight and length, the length of the pendulum, and the train of subjects therewith connected; all which afforded him opportunities of displaying a skill not less consummate as a physical experimenter, than he had already shewn as a mathematician and astronomer.

His first step in this career was the determination of the length of the simple pendulum at his own observatory. The principle of this determination is the observation of the times of vibration of two pendulums whose difference is precisely equal to a given

standard of length; for which purpose a fac-simile of the toise of Peru was chosen, being a measure *aux bouts* which the principle of construction of the apparatus rendered a necessary condition. The actual vibrating pendulum was a ball suspended by a wire, the suspending apparatus being made to rest alternately on the upper end of the toise and on the flat support of its lower end, the tangent plane of the lower surface of the ball being brought to a constant level by the use of the lever of contact. The series of experiments made with this apparatus was published in the volume of *Memoirs of the Berlin Academy* for 1826, though the date of their communication and reading was two years later, the publication of the Memoirs being so much in arrear. This investigation will always be considered as forming an epoch in the history of pendulum experiments, on account of the peculiar mode in which the subject of the resistance of the air to the motion of the suspended body is taken into consideration; this renders it necessary to estimate as part of the mass set in motion the weight of the air dragged along with it. The researches of Mr. Baily and Col. Sabine have fully confirmed the necessity of taking into account this essential though small correction.

The determination of the same important element for the then newly erected observatory at Berlin followed in 1835. The method employed, with some slight improvements, was the same as that practiced at Königsberg, and the whole process will be found in the *Memoirs of the Berlin Academy* for 1835.

The interim between these two determinations, was occupied with a series of pendulum experiments of very especial physical interest and importance—a rigorous inquiry, namely, into the fundamental question whether gravity be really, in all kinds of bodies, proportional to their inertia *solely?* or, in other words, whether or not there be any thing specific or dependent on the intimate nature or chemical constitution of a body which determines the energy of its gravitating power,* the *inertia* being given? The experiments of Newton, though they preclude all idea of any considerable or palpable amount of such specific difference among bodies, could by no means be regarded as sufficiently exact to settle a point of such vast importance with that decision which modern science requires. All idea of such specific attraction is, however, completely done away with by the result of the elaborate series of experiments set on foot by M. Bessel for this purpose, which form the subject of a Memoir pre-

* It is so easy to misunderstand the true gist of this inquiry, that it may be not amiss to state it otherwise. Suppose *a pound* of gold, *a pound* of lead, and *a pound* of ice to be formed into three spheres, and placed with their centres at the three angles of an equilateral triangle,—will they or will they not, taking two by two, attract *each other* with equal forces? The *earth* is here considered as an impartial mixture of all elementary substances.

sented to the Berlin Academy in 1832, and printed in their Memoirs for 1830; every substance examined, including meteoric iron and stony masses, having given exactly the same coefficient of gravitating intensity as compared with its inertia.

Immediately connected with the length of the seconds' pendulum is the determination of standards of weight and measure. The fixation of the Prussian standard of length, ordered by law in 1816, after remaining nineteen years in abeyance, was committed to M. Bessel in 1835, who completed the task assigned to him, in 1837. The account of this operation, and of the comparison of the new standard with the Peru toise, which had served for the measure of the pendulum, forms the subject of a Memoir printed in 1839 by order of the Prussian government.

Eminent as were his mathematical resources, and his aptitude for bringing them to bear in the most advantageous and effective manner upon every point of practical application, there is, perhaps, no subject, among the multitude of those which at different times engaged his attention, in which these qualities were more singularly called into action, in combination with his skill as an astronomer and his perfect knowledge of instruments, than in the geodesical operations which he was about this period called upon to conduct, in conjunction with General Baeyer, for the triangulation of Eastern Prussia. Though the actual extent of this triangulation was not considerable, the extreme points connected being only about 120 English miles distant, still few trigonometrical operations have been executed of greater circumstantial importance, inasmuch as it had for its especial object to connect the operations of Struve in the north of Russia and Finland, and those of von Tenner in the south of that empire, with those of Western and Southern Europe, from which they previously stood altogether disjoined. The triangulation of Hessia, Thuringia, Brandenburg, and Silesia, under the direction of General Müffling, had connected the Hanoverian and Danish measurements on the one hand, and those of France (and consequently also of Britain) on the other, with the Bavarian and Austrian surveys. The chain of connexion had, moreover, been carried on by the triangulation of Western Prussia and the Grand Duchy of Posen, as far as the borders of the Frische Haff, on the Baltic; and one link only was wanting between Trunz, the furthest point of this last-mentioned operation, and Memel, to bring together these detached masses, and bind them into one vast European combination. Bessel's conduct of this operation was marked, like every thing which he undertook, by the adoption of new and refined processes, both of observation and computation. The astronomical latitudes of his stations, for instance, were ascertained by the application of that peculiar mode of using the transit instrument to which allusion has already been made, to the exclusion of the

zenith sector and repeating circle, which had hitherto been used for that purpose. As respects the calculation of the triangles, also, a general mode of treatment was now, for the first time, adopted, combining the whole system of observations in all the triangles, so as to lead to a single conclusion as to the final results of the total work, and not (as had been the practice in all previous cases) to derive by several distinct combinations several distinct conclusions, either as to the whole or to subordinate parts. In the method pursued, each triangle is supposed affected with unknown or rather indeterminate errors in all its angles. The observations of the angles in each, with the application of the spheroidical excess, gives a sum to which all the errors must conform *as nearly as possible*. In the language of modern computation, it affords an *equation of condition* which takes its place and acquires its due influence as an element of a final system of similar equations, whose joint solution is then accomplished by the application of that powerful process, the method of least squares, to which our knowledge of physical truth is so much indebted. In the measurement of the base, also, much ingenious contrivance and many peculiar features occur; and the operation, taken all together, will ever be regarded, apart from its adventitious circumstances of interest, as one of the most instructive geodesical measurements which has ever been performed.

These occupations unavoidably drew the attention of Bessel to the general subject of the figure of the earth, as resulting from geodesical measurements, and more especially to the best and most effectual means of availing ourselves of the vast accumulation of data obtained at such enormous cost and labor, in India, in France, in Britain, and elsewhere. To grasp the whole of this mass under one general and systematic process of reduction and calculation appeared to him an object worthy of his powers, and this design was carried out in that powerful, regular, and at the same time highly artificial mode which had now become habitual to him, in a series of Memoirs communicated to the *Astron. Nachr.*, 333–6, 338. The first of these contains the general exhibition of the most advantageous mode of combining the several independent measures of meridian arcs, so as to obtain by the method of least squares the most probable result as to the dimensions of the terrestrial spheroid, and applies that method to the received values of the arcs, as given by their several measurers, taking for granted the correctness of their computation of their own triangles, and the latitudes of their extreme points. But he did not stop here. On the contrary, engaging deeper in the inquiry, he was led to enter upon a recomputation of the latitudes of all the principal stations in the British and Indian arcs, and finally to recompute entirely, according to the same principle of combination used in his own East Prussian triangulation, the

whole system of French triangles between Montjouy and Formentera. There is, perhaps, hardly one of his numerous and laborious works calculated to give a better idea of the extreme scrupulousness of all his proceedings, and his contempt of labor where the object is to elicit truth in its most absolute form from a mass of observations of undoubted excellence, than this last computation. A mistake, as is well known, had been committed in one part of the computation of the French triangles, by which the total distance between the parallels of these two points had been rendered erroneous to the extent of nearly seventy toises. The mistake, however, had been rectified by the independent calculations of four eminent French geodesists, and their conclusions agreed within three or four toises of each other. This, however, did not satisfy Bessel, and he actually recalculated the whole of the work by his own method, producing a result agreeing with the mean of the four determinations alluded to within a fraction of a toise.

We are still very far from having exhausted the long catalogue of Bessel's astronomical labors. His memoir on the precession of the equinoxes, honored with a prize by the Berlin Academy, and his researches on the planetary perturbations, might well demand some especial notice, did not our necessary limits forbid it, and oblige us also to pass unmentioned, otherwise than generally, the astonishing host of contributions with which, from time to time, he enriched the periodical literature of astronomy. The greater proportion of these are contained in the *Astronomische Nachrichten*—so great a number indeed, and many of them of such extent, that perhaps it is not exaggerating to say that at least a fifth part of that collection, (now consisting of twenty-four volumes,) has emanated from his pen. The *Zeitschrift für Astronomie*, the *Königsberger Archiv für Naturwissenschaften*, the *Monathliche Correspondenz*, and the Supplements to the *Berlin Ephemeris*, contain also many and valuable communications from him.* And when it is recollected that many of these papers are essays of great length and deep interest, abounding in profound research and new conceptions on almost every subject with which astronomers are conversant, we shall see cause to admire no less the indefatigable industry of the man than the extent and versatility of those powers which produced such a profusion of valuable matter. Some of these essays, retouched and enlarged, form part of a work entitled *Astronomische Untersuchungen*, or Astronomical Researches, two volumes of which have appeared, and a third was understood to be in preparation when his labors were arrested by illness.

* In Poggendorff's *Annalen der Physik*, occur occasional communications by Bessel: among others, a long and interesting one in vol. lxxxii, (vi, N. S.,) on the adjustment of thermometers.

In the year 1842, Bessel for the first and last time, visited England, and was received in a manner befitting the high estimation in which his merits were held. His unaffected and pleasing deportment, the charm of his conversation, and the rich fund of information and instruction it afforded, will be remembered with pleasure and regret by all who had the good fortune to be in his company.

There can be little doubt that he was preparing, on his return to Germany, and perhaps even before his visit to England, for an attack upon that great problem whose solution has done so much honor to Le Verrier and Adams. He had, in fact, with a view to this undertaking, engaged a young and promising astronomer, Mr. Flemming, to reduce anew, with the utmost rigor, all known observations of *Uranus*, including the Königsberg observations of that planet, and to compare them with the tables. This was the groundwork of his intended researches. Mr. Flemming completed the reductions, which are in the possession of Mr. Schumacher, and died soon afterwards, and the fatal malady of which, after two years of continually increasing suffering, Bessel himself died, made its appearance, and interdicted every serious labor.

The scientific character of Bessel will have been easily collected from what has been said of particular branches of his extensive labors. One leading feature of it was the concentration of all known data on each particular subject of inquiry, with the view of expressing from them, by the highest and most refined application of mathematical and computistic power, the utmost they are capable of affording in the direction of numerical precision; and as a means to this end, to satisfy this earnest longing after precise results, an equally earnest and successful endeavor to improve to the utmost all formulæ and systems of computations *as such;* that is to say, to put them before the computist in a state ready for immediate use, and to give the last precision which the state of science admits to every fundamental and every derivative coefficient. In the preface to his *Untersuchungen*, he says of himself, that he at no time felt any especial predilection for one rather than another particular branch of astronomical occupation, but that one idea was continually present to his mind—that of always working up to an *immediate* and *definite* object; either that of arriving at some positive result, more perfect than what before had been obtained, or that of removing some acknowledged obstacle which opposed at once the improvement of more than one subject. And in this remarkable passage he goes on to declare, that the desire of merely accumulating data by observation, without the intention of using them to such ends, was altogether alien to his tastes; and that the deduction of actual results from observations, by the observer himself, with a

distinct view to the improvement of knowledge, appeared to him, at all times, an essential condition of success in all astronomical research.

As a mathematician, Bessel takes, undoubtedly, a high rank; not, indeed, as an original inventor in the abstract walks of the pure analysis, but always with a view to applications, in which, whatever occasion required its exertion, his skill was never found unequal to the task on hand, no matter what its difficulty. As a practical astronomer, his knowledge of what may be called the theory of instruments—the mode of detecting, compensating, and eliminating their errors; the influence of flexures of their limbs, tubes, and other parts; and his acquaintance with, and constant practice of, every delicacy in their use, were such as has never been surpassed. Equally great in perfecting old methods of observation and in suggesting new, the practice of the modern German school of astronomers is almost emphatically Bessel's practice; and he was deservedly looked upon as a guide and model, not only in Germany but by Europe.

Bessel was, of course, elected into almost every academy in Europe as an Associate. He became a Foreign Member of this Society in 1822. As he advanced in years and in reputation, distinctions of a different kind were conferred upon him; among others, the order of the Dannebrog by the King of Denmark, and that of the Red Eagle, with the title of "Geheimer Regierung's Rath," and the order of Civil Merit by his own sovereign, whose favor he constantly experienced, and whose attentions during his last illness were of the most benignant kind, and soothed, though they could not alleviate his sufferings.

---

## Art. XXIII.—*On the Properties of Ozone;* by C. F. Schönbein.*

By a number of experiments made by myself and repeated by others, it has been demonstrated that ozone (which I take for a peroxyd of hydrogen, and Berzelius for pure oxygen in a peculiar condition) is the most powerful oxydizing agent we at present know of. A most striking instance of its exalted chemical powers is the fact, that metallic silver being in a state of minute mechanical division and put in contact with ozone, is readily transformed into the peroxyd of the metal even at very low temperatures. The several facts I have lately ascertained, and which I am going to state, will give further proofs of that power.

---

* Communicated for this Journal, by Prof. Schönbein, in a letter to Prof. Silliman, dated Bâle, July 15, 1847, and received through Prof. Beck of Cambridge, Mass.

1. Ozone has the property of decomposing the protoxyd salts of manganese, throwing down that metal in the shape of the hydrate of peroxyd of manganese and setting at liberty the acids of the said salts. If aqueous solutions of sulphate, nitrate and muriate of manganese be shaken with atmospheric air which has been strongly ozonized in the usual manner, (by means of phosphorus,) ozone rapidly disappears, the saline solutions become turbid, hydrate of peroxyd of manganese is precipitated in the shape of little scales of a brownish color, and sulphuric, nitric or muriatic acid set at liberty. To cause the decomposition described, it is not required to dissolve the salts, the latter being acted upon by ozone even in their solid state. I make use of this remarkable property of ozone to prepare a specific and delicate test for that curious substance. Small strips of the whitest filtering paper are drenched with a weak solution of sulphate of protoxyd of manganese, suffered to dry, and kept in stoppered bottles.

On introducing such paper into ozonized air, it rapidly assumes a brownish tint, growing darker and darker, the longer the test paper is left suspended within the air. If the atmosphere happens to be strongly ozonized, the discoloration makes its appearance after a few seconds suspension. I hardly need mention that the test paper turns brown when exposed to the action of oxygen, which has been obtained by the electrolysis of water, and exhibits the peculiar electrical smell. The said paper may also be used to prove that ozone is formed by electrical discharges taking place either in oxygen or atmospheric air. By exposing a bit of test paper to the action of the electrical brush, (playing in air or oxygen,) it undergoes the same change of color as it does within air ozonized by phosphorus, or within the oxygen produced by electrolysing water. But as under the first mentioned circumstances, only very small quantities of ozone are generated, it requires rather a long action of the electrical brush to turn the test paper brown.

Electrical discharges continually taking place in our atmosphere, and ozone being invariably produced by them, it necessarily follows that some small portions of that oxydizing agent are present in atmospheric air. The correctness of that conclusion is most easily proved by the means of my test paper; for on being exposed to the action of free circulating air, it gradually assumes a brown tint, whilst the paper remains perfectly white, when kept inclosed within a bottle filled with atmospheric air. According to the state of the atmosphere, the test paper is comparatively more or less rapidly turned brown, but always slowly. I have strips of paper which have been very perceptibly turned brown, after a week's exposure to the open air.

I have tried to produce images by drawing with a solution of sulphate of manganese upon paper, and exposing the latter (when dry) to the action of atmospheric air which has previously been strongly ozonized by the means of phosphorus; and I may say that I have obtained very pretty results. The drawing or writing comes out within a few minutes, first exhibiting a yellowish tint and afterwards a deep brown shade. Gaseous sulphurous acid, readily uniting with the hydrate of peroxyd of manganese to form colorless sulphate and hypo-sulphate of manganese, these manganese images or writings may be almost instantaneously destroyed by introducing them into a bottle containing some gaseous sulphurous acid. And it is a matter of course that the images thus extinguished are restored by reëxposing them to the action of ozonized air. These reactions may be used for making very pretty class-room experiments to show the action of ozone upon manganese salts, and that of sulphurous acid upon peroxyd of manganese. They will perhaps also allow of a practical application. I may add that my test paper after having been turned slightly brown by ozone serves as a test for sulphurous acid.

2. Ozone enjoying so many properties in common with chlorine and bromine, I suspected the two latter bodies would act like ozone upon the solutions of manganese salts, and found my conjecture confirmed by experiment. If aqueous chlorine or bromine is mixed up with a solution of sulphate, nitrate or muriate of manganese, a very slight action takes place in the dark, but no sooner has the mixture been exposed to the action of solar light than a reaction begins and peroxyd of manganese is thrown down.

3. Sufficient quantities of ozonized air being treated with a solution of basic acetate of lead (extractum Saturni), throw down all the excess of oxyd of lead in the shape of the brown peroxyd transforming the basic salt into a neutral one. Chlorine and bromine act in a similar manner. If aqueous chlorine or bromine be added to a solution of the subacetate mentioned, until the whole precipitate first formed has disappeared, and the mixture becomes limpid again, very soon after, the liquid will become turbid, peroxyd of lead being thrown down. To show these reactions in the most simple manner, I drench strips of white filtering paper with a solution of the subacetate and suspend them in bottles, containing some ozone, chlorine or bromine. After a certain time these strips will have assumed a brown color resulting from the peroxyd of lead formed under these circumstances.

4. Ozone has the power of forming permanganic acid under the following circumstances. If the bottom of a large bottle filled with atmospheric air be covered with a solution of sulphate of manganese and a bit of phosphorus having a clean surface be placed

in the solution so that about half its bulk rises above the fluid, the formation of ozone will immediately ensue, provided the temperature be 15° to 20° R. Part of the ozone formed, acts upon the saline solution and transforms part of its protoxyd of manganese into permanganic acids, whose presence is indicated by the beautiful deep red color which the solution assumes in the course of a few hours. The same richly colored fluid is obtained by shaking a solution of sulphate of manganese or any other manganese salts in dilute phosphoric acid with ozonized air.

Having drawn up a detailed account of these and other experiments, which before long will be published in "Poggendorff's Annalen," I take the liberty to refer the readers of your periodical to that Journal.

Enclosed you will find some specimens of manganese drawings and writings produced in the manner above described. By exposing them for a short time to the action of gaseous sulphurous acid, you may easily destroy the image, &c., and restore them, by ozonized air.

---

## Art. XXIV.—*Ancient Sea Margins;* by Robert Chambers.

TO THE EDITORS OF THE AMERICAN JOURNAL OF SCIENCE AND ARTS.

1 Donne Terrace, Edinburgh, July 9. 1847.

*Gentlemen:*—I beg, through the medium of your pages, to call the attention of American geologists to a line of investigation, from which I have been led by inquiries of my own in this country, to expect some important results. It is that of natural terraces, *benches* of land, and other forms of the surface, which appear to indicate the former presence of the margin of the sea. Hitherto ancient beaches have been chiefly inferred from the presence of shells, but I am satisfied from my researches here, that they can be detected with equal certainty from the configuration of the ground and the presence of sand, gravel, and other materials, such as are usually found on beaches. In Scotland, I have by this means ascertained the existence of a series of ancient beaches, from 64 to 616 feet above the level of the sea at high water of ordinary tides, besides a few at inferior elevations, but too much huddled to be described with precision. And these are not marked at one place only, but many of them appear at various places all around the island. In each several place they are perfectly horizontal in the line of the ancient coast. In some places, two, three, and four, may be distinctly traced on one hill-face towards the sea, or in a valley which had formerly been the bed of an estuary. Precisely the same group seldom appears in two

such places—though several of them are remarkably persistent. More generally, one of those present at place A is wanting at place B, while another is perhaps substituted. There is no difficulty, however, in seeing that those common to the two situations are the memorials of one set of pauses of the sea, as they always appear at certain elevations, with intervals which, though in some cases small, are always peculiar and characteristic. In short, there is here evidence that the process by which the relative level of sea and land has changed in our island at the era of the superficial formations, was one which did not move the land in the slightest degree off the plane which it had previously occupied.

I need scarcely remark, that, in consequence of what we have heard for some years, of the unequal changes of relative level in South America and Scandinavia, every step of this investigation was attended by a battle with my prepossessions. The facts, however, are of so clear and palpable a nature, that there is no gainstanding them. And perhaps there is no necessary inconsistency between them and the observations of Messrs. Darwin and Lyell. Any how, it has appeared to me exceedingly desirable to learn how far this uniformity has prevailed, and I have therefore visited France and Ireland, in order to search for terraces and ascertain their heights. You may believe it was with no common emotions that I found in these countries terraces broadly marked and characteristically grouped as in Scotland, and at precisely the same elevations,—proving that France and Ireland stood in the same predicament as the island of Great Britain with respect to the change of the sea level, by whatever means that had been brought about.

Since then I have been led to inquire after the heights of the terraces of more distant regions, particularly Scandinavia and North America; and certain it is, however startling and unexpected, that there are appearances as if the uniformity extended even thus far. I am anxious to speak on this point with caution, and with full preparation for evidence to a different effect. Yet amidst all the obscurity of observations made with no regard to this point, and which coming from different minds must needs bear some incompatibilities, there does appear enough at least to awake a strong suspicion of the uniformity in question, and to make me feel quite unjustifiable in refraining from further enquiry. For instance, a *sixty feet beach* is described at Fossum in Norway, and in the Mindar islands in the Gulf of the St. Lawrence. The phrase might describe a geognostic feature of this island, than which I do not know any more remarkable. I find also, in a paper by the Profs. Rogers, on the tertiary formations of Eastern Virginia, (*Trans. Am. Soc.*, 1839,) a description of what they call a *bench* of land (one of my own phrases) between the rivers

Potomac and Rappahannock, which, besides being *from sixty to seventy feet high* over several miles, is in the main lithologically a perfect counterpart to many examples of the terrace at the same height on the British coasts. There are even more striking coincidences than these. The gravel plain at West Point, if it can be considered as connected with the sea margin of a former era, is in harmony with one of the greatest of the British terraces. Nay, among the elevated terraces which Mr. Roe has described as stretching along the sides of Lake Ontario, there are some which come surprisingly near to certain similar formations which others have described in this country. There may be nothing here but accidental coincidence; indeed it may be admitted that most probably there is nothing else in the case. It were well, nevertheless, to make sure.

For this purpose, I now beg to suggest to the geologists of America, the propriety of examining such examples of ancient beaches as may be within reach in their several districts, with a view to settling the question one way or another. To all in America who have written on kindred subjects, I would respectfully recommend this inquiry, than which none could be more easily conducted. The first point should be, to find other instances of the sixty-four feet beach; in this country it is usually a broad terrace of sandy or gravelly materials, presented towards the sea or along the banks of tidal rivers. If really a general feature of America, as of Britain and Ireland, I should expect it to be found in many situations along the banks of the Hudson. An examination of the form and constitution of this terrace will fit the enquirer for discovering the higher beaches; to which, however, I do not think it proper to attempt affording any guide by the elevations of those found in Scotland, as obviously, if there be any correspondences these will have more force as evidence, if we can say that the two sets of facts were arrived at independently. I shall only remark that terraces between one hundred and fifty and three hundred feet are more likely to be efficient as tests than any of lower altitude excepting only the sixty-four feet beach, because in that higher range of elevations the intervals are wide and more characteristic. Accurate measurements by levelling from a certain specified datum are of course desirable, and the results should be published from time to time. I need scarcely say how much gratified I should feel by any communications to myself upon the subject.

## Art. XXV.—*Glycocoll (Gelatine Sugar) and some of its Products of Decomposition;* by Prof. E. N. Horsford.

(Concluded from p. 70.)

### Products of Decomposition of Glycocoll.

#### *Action of Sulphuric Acid.*

As glycocoll contains the elements of fumarate of ammonia,

$$C_4\,H_4\,NO_3,\ HO{=}NH_4\,O,\ C_4\,HO_3,$$

it was conceivable that the employment of the appropriate agencies might effect a simple decomposition into these two members. Neither potash nor baryta, however, were found capable of expelling the ammonia. But upon dissolving in diluted sulphuric acid, and evaporation by heat to syrup consistence, redissolving with water, again evaporating, and repeating this process several times, at a certain stage, not definitely ascertained, the whole crystallizes in forms of great beauty;—which when washed with alcohol and pulverized, with addition of potash yield ammonia.

Some of the crystals were nearly cubic, reminding one of chlorid of sodium, others were rhombic with feathered margins. They taste and react acid, and do not change upon exposure to the air.

Dried over sulphuric acid and analyzed, they gave the following results.

I. 0·4302 grm. of sub. gave 0·2031 carb. acid and 0·2099 water.
II. 0·3526 " " " 0·8062 platin-salammoniac.
III. 0·3574 " " " 0·8300 platin-salammoniac.
IV. 0·4958 " " " 0·6090 sulphate of baryta.

Expressed in per cents.

| | I. | II. | III. | IV. |
|---|---|---|---|---|
| Carbon, | 12·87 | . . | . . | . . |
| Hydrogen, | 5·42 | . . | . . | . . |
| Nitrogen, | . . | 14·40 | 14·63 | . . |
| Sulph. acid, | . . | . . | . . | 41·85 |

These numbers give the formula:

$$C_4\,H_4\,NO_3,\ SO_3,\ HO{+}NH_4O,\ SO_3\,HO,$$

as the juxtaposition of the per cents. of analysis and those derived from direct estimate will show:

| | | Theory. | Experiment. |
|---|---|---|---|
| Carbon, | 4 equiv. = 24 | 12·36 | 12·87 |
| Hydrogen, | 10 " = 10 | 5·26 | 5·42 |
| Nitrogen, | 2 " = 28 | 14·73 | 14·52 |
| Oxygen, | 6 " = 48 | 25·04 | 25·58 |
| Sulphuric acid, | 2 " = 80 | 42·10 | 41·85 |
| | 190 | 100·00 | 100·00 |

This result supported the view that glycocoll contained not only the elements of fumaric acid and ammonia, but contained them in such form or arrangement, as would yield to an active affinity aided by heat.

It was highly probable, therefore, that galvanic action alone would be adequate to the task of decomposition.

To submit this query to the test of experiment, a solution of glycocoll was exposed to the *action of a galvanic battery*, consisting of four of Bunsen's pairs. The solution was separated by a membrane from the water. Upon closing the circle and plunging the poles terminated with platinum plate, one into the solution of glycocoll and the other into the water without, an instantaneous evolution of gas bubbles, at each pole succeded. After the action had continued a short time the fluid about the negative pole gave an alkaline reaction, while that about the positive pole gave an acid reaction. There could then scarcely a doubt remain, that glycocoll was a salt of which the base was ammonia and the acid a body identical in constitution with fumaric acid.

To obtain this acid, glycocoll was treated several hours, over a moderate heat with sulphuric acid, in the manner above described—repeatedly diluting and evaporating. The sulphuric acid for the most part was thrown down with oxyd of lead, and the last traces accurately removed with solution of baryta. The filtrate was then evaporated to concentration over sulphuric acid. In a few hours rhombic prisms of unexampled beauty and perfection, of the combination, $\infty P$, $OP$, crystallized from the solution.

Their taste was exceedingly sour. In water they dissolved with difficulty and in ether and alcohol they were absolutely insoluble. With potash, ammonia was evolved from them.

Combustion with chromate of lead, gave the following results.

I. 0·1922 grm. of sub. gave 0·1048 carb. acid and 0·1008 water.

II. 0·2350 " " " 0·5700 platin-salammoniac.

| or in per cent.: | I. | II. |
|---|---|---|
| Carbon, | 14·86 | . . |
| Hydrogen, | 5·82 | . . |
| Nitrogen, | . . | 15·28 |

With these results it was found impossible to construct any formula, containing only the elements of glycocoll, that could have been derived from the action of sulphuric acid. The first action of the acid would be the abstraction of ammonia.

$$C_4 H_5 NO_4 - NH_3 = C_4 H_3 O_4.$$

If in excess it was conceivable that the remaining member would be subdivided, giving oxalic acid and an oxyd of the radical of Dumas' alcohol and ether series.

$$C_4 H_3 O_4 = C_2 O_3 + C_2 H_3 O.$$

The latter uniting with sulphuric acid would give a compound that might not be thrown down by baryta and which with the ammonia, after the precipitation of oxalic acid would give—

$$C_2\ H_2\ O,\ SO_3,\ NH_4\ O.$$

Upon heating the body with potash—dissolving in hydrochloric acid and adding baryta, a copious precipitate followed, establishing the presence of sulphuric acid. The small quantity prepared, prevented a determination of the quantity of acid. This formula requires 13·86 p. c. of carbon, 16·36 of nitrogen, and 6·81 p. c. of hydrogen.

It is not considered as established but merely as indicating approximately the action of sulphuric acid.

A concentrated solution of the crystals gave with baryta a crystalline precipitate that redissolved in hydrochloric acid.

With chlorid of calcium, upon the addition of ammonia, a crystalline precipitate was thrown down.

Want of time as well as of substance, postponed the further examination of this interesting body.

### *Action of Chlorine.**

When a moderately concentrated solution of glycocoll is subjected to a current of chlorine gas, the latter is rapidly absorbed, and an instantaneous and copious evolution of carbonic acid succeeds. Heat and sunlight both facilitate the action. A convenient method was found in connecting with a stream of dry chlorine gas, a Liebig's potash apparatus, filled, as far as is usual for a combustion, with a solution of glycocoll. It is only necessary that the rapidity of evolution equal that of absorption.

At the end of the third day the process was interrupted, and the liquid evaporated to a syrup consistence. A drop of this syrup yielded, upon the addition of ammonia, a white crystalline precipitate with both chlorids of barium and calcium.

Upon saturating with baryta, filtering and washing with absolute alcohol, it was found that but a small fraction of the glycocoll had been oxydated.

It was again returned to the potash apparatus, and exposed to a slow but uninterrupted stream of chlorine gas for a week. At the conclusion of this period there was still glycocoll unchanged. Chlorid of barium gave the precipitate from the concentrated solution after neutralization with ammonia. This precipitate redissolved in water. It also redissolved in nitric acid, from which it was not thrown down by ammonia.

---

* Mulder did not observe any action of chlorine upon glycocoll; a circumstance attributable possibly to the presence of an impurity rich in hydrogen, or to the action not being continued sufficiently long.

When washed and dried the baryta compound was no longer soluble in water, not even with long continued boiling. It was however promptly dissolved in dilute hydrochloric acid. It contains neither chlorine nor nitrogen.

The baryta salt alone was analyzed.

Combustion with chromate of lead gave from—

I. 0·3218 grm. of sub. 0·1544 carb. acid and 0·0547 water.

II. 0·6627 " " 0·5210 sulphate of baryta.

The only formula which can be derived from these determinations is—

$$C_3\,H_3\,O_6 + BaO.$$

Which requires:

| | | Estimated. | Found. |
|---|---|---|---|
| Carbon, - - - - | 3 equiv. = 18 | 12·36 | 13·08 |
| Hydrogen, - - - - | 3 " = 3 | 2·05 | 1·89 |
| Oxygen, - - - - | 6 " = 48 | 32·99 | 33·38 |
| Baryta, - - - - | 1 " = 76·6 | 52·60 | 51·65 |
| | 145·6 | 100·00 | 100·00 |

The same remarks are applicable to this formula that have been made concerning the preceding.

It is recorded chiefly to show that chlorine does not act upon glycocoll as upon many other bodies, by which a certain number of atoms of hydrogen are replaced by an equal number of atoms of chlorine.

The action may be conceived to be the following:—

$$C_4\,H_4\,No_3 + 5HO + 3Cl = C_3\,H_3\,O_6 + NH_4\,Cl + Co_2 + 2HCl.$$

The same body was obtained by direct addition of a solution of *permanganate of potassa* to an aqueous solution of glycocoll.

After boiling a length of time with *nitric acid*, the same product of decomposition was formed.

When pulverized *chlorate of potash* in small quantity and at intervals is added to a solution of glycocoll in hydrochloric acid, a slow oxydation goes forward, and a product is obtained, in which, as in the cases above noticed, baryta gives apparently the same white crystalline precipitate.

### *Action of Caustic Potash.*

The brilliant fire red color assumed by glycocoll when heated with caustic potash, has already been noticed. If the solution be evaporated to extreme concentration, the evolution of ammonia and hydrogen continues, until at length the mass becomes solid. When treated with hydrochloric acid, hydrocyanic acid is evolved, and if iron salts be present Berlin blue is formed. When dissolved in water the addition of chlorid of calcium is followed by an instantaneous white precipitate, which does not dissolve in acetic acid—a precipitate of oxalate of lime.

The decomposition may be illustrated by the following scheme:—

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 equiv. | cyanogen, . . | $C_2$ | . . | N | . . |
| 1 " | ammonia, . . | . . | $H_3$ | N | . . |
| 2 " | oxalic acid, . . | $C_4$ | . . | . . | $O_6$ |
| 2 " | carbonic oxyd, . | $C_2$ | . . | . . | $O_2$ |
| 7 " | hydrogen, . . | . . | $H_7$ | . . | . . |
| 2 " | glycocoll, . . | $C_8$ | $H_{10}$ | $N_2$ | $O_8$ |

*Glycocoll and Hydrosulphuric Acid.*

The readiness with which glycocoll enters into combination, and the interest attaching to sulphur compounds in the products of decomposition in the organism, suggested the treatment with hydrosulphuric acid.

Taurin, according to Redtenbacher,* is—

$$C_4\,H_7\,NO_6\,S_2$$

which he observed contained the elements of two atoms of sulphurous acid, aldehyde, and ammonia:

$$C_4\,H_7\,NO_6\,S_2 = C_4\,H_3\,O,\,NH_4\,O,\,S_2\,O_4.$$

The union of these several ingredients he succeeded in effecting.

Taurin also contains the elements of hydrated glycocoll, two atoms of water and two of sulphur:

$$C_4\,H_7\,NO_6,\,S_2 = C_4\,H_5\,NO_4,\,2HO,\,S_2.$$

It was conceivable that by treating a solution of glycocoll with hydrosulphuric acid, and exposing the product to oxydation, a compound, consisting of glycocoll, water, and sulphur in the above relations, might be obtained.

Two atoms of Cystine:

$$2(C_6\,H_6\,NO_4\,S_2)$$

contain the elements of three atoms of hydrated glycocoll, from which ammonia has been withdrawn, and in which four atoms of oxygen have been replaced by an equal number of atoms of sulphur:

$$C_{12}\,H_{12}\,N_2\,O_8\,S_4 = C_{12}\,H_{15}\,N_3\,O_{12} + S_4 - NH_3 - O_4$$
$$= 2(C_6\,H_6\,NO_4\,S_2).$$

The evolution of the latter product was also not impossible.

Long continued and repeated efforts, however, gave no awaited result; the hydrated glycocoll recrystallizing from the solution with neither accession nor loss.

To obtain either of the above results another experiment was made.

* Liebig's Annalen, Bd. lvii, s. 170.

Glycocoll was dissolved in quinqui-sulphid of potassium, spirits of wine added, and the solution evaporated through several weeks, over sulphuric acid, to dryness.

An efflorescence had crept up the sides of the containing vessel and the bottom was covered with crystals. Upon treating the whole with hot water, sulphur was separated, which was filtered off and the filtrate slowly evaporated to syrup consistence, from which the whole became a solid crystalline mass.

To a solution of the crystals, addition of sulphuric acid caused the evolution of sulphurous acid and the separation of sulphur. Here was the usual product of exposing the quinqui-sulphid of potassium to the air—hyposulphite of potash.

Upon adding bi-chlorid of platinum to a second portion, a precipitate of platin-chlorid of potassium followed, without the evolution of sulphurous acid or separation of sulphur. There was then left in the solution—

$$C_4\ H_4\ NO_3,\ HO,\ S_2\ O_2,$$

which equals,

$$C_4\ H_7\ NO_6\ S_2 - H_2.$$

### Constitution of Glycocoll.

The enquiry presses itself, where in the general subdivisions of chemistry does glycocoll belong? Is it a base? Is it an acid? Or is it a salt?

The combinations into which it is capable of entering seem only to embarrass reply.

The following table of the principal compounds of glycocoll that have been analyzed, and the adjoining table of corresponding compounds, chiefly from inorganic chemistry, will not be without interest in the determination of this question.

*As an Acid.*

| | |
|---|---|
| $C_4\ H_4\ NO_3$, CuO (Aq) | $SO_3$, CuO |
| $C_4\ H_4\ NO_3$, PbO " | $SO_3$, PbO |
| $C_4\ H_4\ NO_3$, AqO " | $SO_3$, AgO |

*As a Base.*

*a.*

| | |
|---|---|
| $C_4\ H_4\ NO_3$, $SO_3$ | AgO, $SO_3$ |
| $C_4\ H_4\ NO_3$, $NO_5$ | AgO, $NO_5$ |

*b.*

| | |
|---|---|
| $C_4\ H_4\ NO_3$, $SO_3$, HO | ZnO, $SO_3$, HO |
| $C_4\ H_4\ NO_3$, HCl, HO | BaO, HCl, HO |
| $C_4\ H_4\ NO_3$, $\overline{O}$, HO | KO, $\overline{O}$, HO |

*c.*

$C_4\,H_4\,NO_3, HO, \bar{A}, 2HO \mid NH_3, \bar{A}, 2HO$

*As a Haloid Salt.*

$C_4\,H_4\,NO_2, KCl \mid Hg\,Cl, KCl.$

*As a Bi-chlorid of Platinum.*

$$\begin{array}{l} C_4\,H_4\,NO_2, \overset{+}{Ber}, \overset{+}{HCl} \\ C_4\,H_4\,NO_2, BaCl, (2aq) \end{array} \Big| \begin{array}{l} Pt\,Cl_2, \overset{+}{Ber}, \overset{+}{HCl} \\ Pt\,Cl_2, \overset{+}{Ba}\,\overset{+}{Cl} \end{array}$$

*As Ammonia.*

$C_4\,H_4\,NO_3, PtCl_2\,(2aq) \mid H_6\,N_2, PtCl_2$ (Gros.)
or as haloid salt,
$NH_4\,Cl, PtCl_2$

*As an Amphid Salt.*

$$\begin{array}{l} C_4\,H_4\,NO_3, AgO, NO_5 \\ C_4\,H_4\,NO_3, KO, NO_5 \end{array} \Big| HgO, NO_5 + AgO, NO_5$$

*As of the Magnesia Series.*

$C_4\,H_4\,NO_3, SO_3, KO, SO_3$ . . . . . 1
$C_4\,H_4\,NO_3, SO_3, NH_4\,O, SO_3 + (2aq)$ . . . . 2
1 . . . . . $MgO, SO_3\,KO, SO_3 + (6aq)$
2 . . . . . $MgO, SO_3\,NH_4\,O, SO_3 + (6aq)$

*Basic Salts.*

$$\left.\begin{array}{l} C_4\,H_4\,NO_3, HO \\ 2\,CuO \end{array}\right\} NO_5\,HO \mid 3\,CuO, NO_5\,HO$$

$2\,(C_4\,H_4\,NO_3)\,HCl, HO \mid 2NH_3, Zn\,Cl, HO$

$3\,(C_4\,H_4\,NO_3), 2SO_3, 2HO \mid 3Hg_2\,O, 2NO_5, 3HO$

*And further:*

$C_4\,H_4\,NO_3, HO, AeO, SO_3 \mid SO_3\,HO, AeO, SO_3$

$C_4\,H_5\,NO_3, \bar{U}\,NH_4O, \bar{U} \mid HO, \bar{U}, NH_4O, \bar{U}$

In the above tables we have representatives from almost every class of compounds in the domain of chemistry, and yet they are severally typified in the combinations of glycocoll.

We have it uniting with bases;—a characteristic of acids: uniting with acids;—a characteristic of bases: uniting with amphid salts; a characteristic of amphid salts.

We have it replacing a haloid salt in a binary chlorine compound; playing the part of bichlorid of platinum in another; now appearing in the magnesia series and again replacing water.

It will not be out of place to trace this relationship to other bodies in chemistry a little further, if it may aid in arriving at a nearer conception of the place glycocoll should hold.

The great truth that *the distinguishing properties of bodies depend upon the form, volume and density of their atoms*, or to use another form of expression, that *with every change of these attributes of the atoms, there is a corresponding change in the distinguishing properties of the masses*, is every day acquiring a more profound significance.

The chemical and physical differences between *phosphoric, pyrophosphoric* and *metaphosphoric* acids, are but the counterparts of different forms, volumes and densities assumed by the same elements in the same relative proportions.

The same is true of *cyanic, fulminic* and *cyanuric acids:* of *oxyd of methyle* and *alcohol:* of *hydrated acetic acid* and formate of *oxyd of methyle.*

It is well known that the several members of groups of isomorphous bodies;—the *alums* for example, have many chemical and physical attributes in common. They have also common *form* and *volume.**

It requires but a little expansion of the thought naturally arising from the consideration of these facts, to come upon the enquiry: *are not acids as such, indebted for their distinguishing characteristic to a common peculiarity of form among their atoms; and bases to another for theirs, and salts to another for theirs ?*†

Let this conception be entertained for the moment, and connect with the peculiarities of glycocoll the following considerations.

1. We have already seen that glycocoll contains the elements of *fumarate of ammonia;*

$$C_4\ H_4\ NO_3 = NH_3, C_4\ HO_3.$$

2. It may also be regarded as *cyanate of hydrated oxyd of methyl:*

$$C_4\ H_4\ NO_3 = C_2\ H_4\ O_2, C_2\ NO,$$

a sugar in which alcohol and carbonic acid are replaced by wood-spirit and cyanic acid.

The effort to obtain methyl alcohol by slow distillation of glycocoll from a solution in strong potash, failed.

---

* Mitscherlich and Kopp.

† The following interesting relationship may be worth recording.

$C_4\ H_3 \frac{H}{N} O_3$ = glycocoll.

$C_4\ H_3 \frac{H}{O} O_3 \times 3$ = grape sugar.

$C_4\ H_3 \frac{Pb}{O} O_3$ = sugar of lead.

$C_4\ H_3 \frac{H}{H_2 O_{\frac{1}{3}}} O_3 = \frac{1}{3}$ oxyd of glyceryle.

$C_4\ H_3 \frac{H}{N} O_3\ HO$ = nitrous ether.

These bodies have similar taste. Is it dependent upon the similar arrangement of their smallest particles?

One is here reminded of the large number of acids of this formula (R) $+O_3$. Is the sourness of this class dependent upon a common peculiarity of form?

Dumas has suggested that the compound produced when anhydrous sulphuric acid is conducted into an atmosphere of dry ammonia, may be considered *hydrated sulphite of amidogen:*

$$NH_3, SO_3 = HO, NH_2, SO_2.$$

Kane on the other hand, suggests that it be regarded as *hydrated sulphuric acid*, in which one atom of oxygen is replaced by one atom of amidogen.

$$NH_3, SO_3 = S \left\{ \begin{matrix} O_3 \\ NH_2 \end{matrix} \right\} H.$$

3. Glycocoll may be regarded as a *succinate of amidogen*,

$$C_4 H_4 NO_3 = NH_2, C_4 H_2 O_3,$$

4. Or as *malic acid* in which one atom of oxygen is replaced by amidogen.

$$C_4 H_2 O_4 = \text{atom of malic acid.}$$

$$C_4 H_4 NO_3 = C_4 H_2 \left\{ \begin{matrix} O_3 \\ NH_2 \end{matrix} \right\}$$

5. If doubled it becomes *asparagin.*

$$2\,(C_4 H_4 NO_3) = C_8 H_8 N_2 O_6.$$

Since the atom of water in crystallized glycocoll is replaced by both acids and bases, it may not be impossible to obtain from glycocoll a body identical in elementary composition with asparagin. Instances of metamorphosis of this description are not infrequent in the records of chemical investigation.

The conversion of *styrol* into *metastyrol* by heat* and by vibratory motion† in connection with machinery, is among the most remarkable. The spontaneous change of cyanate of ammonia into urea:‡ of aldehyd into metaldehyd:§ of hydrated cyanic acid into cyammelide:‖ and the reconversion by distillation of cyammelide and cyanuric acid into cyanic acid: the change of alloxan into alloxanic acid: the metamorphoses of phosphoric acid by heat, and other similar phenomena by *contact* with alkalies, lend support to the supposition, that it may yet be possible to effect some of the metamorphoses above suggested—or some which follow.

6. It would not be more unexpected, than was the artificial preparation of urea, to make glycocoll by combining *urea* and *grape sugar.*

$$\underbrace{C_2 H_4 N_2 O_2}_{\text{Urea.}} + \underbrace{C_6 H_6 O_6}_{\text{Half atom of grape sugar.}} = \underbrace{2(C_4 H_5 NO_4)}_{\text{Hydrated glycocoll.}}$$

7. The circumstance that in the preparation of the bisulphate of glycocoll and ammonia, fumaric acid is driven out, leads to

---

* Blythe and Hoffman, Liebig's Annalen, Bd. liii, s. 311.
† Sullivan, Phil. Mag., 1845.
‡ Wöhler. § Liebig. ‖ Liebig and Wöhler.

the following consideration. If upon separating the fumaric acid, it were to unite with uncombined glycocoll, there would arise a compound containing the elements of *asparaginic acid.*

$$\underbrace{C_4\,H_4\,NO_3}_{\text{Fumarate of glycocoll.}}+\underbrace{C_4\,HO_3}=\underbrace{C_8\,H_5\,NO_6}_{\text{Asparaginic acid.}}$$

8. Two atoms of glycocoll contain also the elements of *allophanic ether.**

$$\underbrace{2\,(C_4\,H_4\,NO_3)}_{\text{Glycocoll.}}=\underbrace{C_4\,H_5\,O,}_{\text{Ether.}}\ \underbrace{C_4\,H_3\,N_2\,O_5}_{\text{Allophanic acid.}}$$

9. Hydrated glycocoll contains the elements of *nitric ether.*

$$C_4\,H_4\,NO_3,\,HO=C_4\,H_5\,O,\,NO_3.$$

Here are two bodies of the most opposite properties, one fluid and volatile, the other solid and cannot be sublimed.

We have a similar instance in the two forms of chlorid of cyanogen; the volatile discovered by Gay Lussac and the solid by Serrullas.

We have another in aldehyd and metaldehyd—a liquid and a solid body.

10. Two atoms of glycocoll and one of ammonia contain the elements of the *creatine* of Chevreul, recently analyzed by Liebig.

$$\underbrace{2(C_4\,H_4\,NO_3)}_{\text{Glycocoll.}}+NH_3=\underbrace{C_8\,H_{11}\,N_3\,O_6}_{\text{Creatine.}}$$

11. The base derived, by Liebig, from creatine, by boiling with baryta water, which separates urea (as $CO_2$ and $NH_3$), contains the elements of glycocoll and oxyd of methyl. It contains also the elements of the Lactamide of Pelouze.

$$\underbrace{C_8\,H_{11}\,N_3\,O_6}_{\text{Creatine.}}-\underbrace{C_2\,H_4\,N_2\,O_2}_{\text{Urea.}}=\underbrace{C_6\,H_7\,NO_4}_{\text{New base.}}=\underbrace{C_4\,H_4\,NO_3,}_{\text{Glycocoll}}$$

$$\underbrace{C_2\,H_3O}_{\text{Oxyd of methyl.}}=\underbrace{C_6\,H_5\,O_4,\,NH_2}_{\text{Lactamide.}}$$

It will no longer seem strange that a body having so many relationships as are here exhibited, should find its place in the established classes of chemical compounds with difficulty.

The conclusion to which we have arrived in the progress of the investigation above recorded, is, that glycocoll may at the same time be an *acid*, a *base*, and a *salt*, since it has properties in common with each, that distinguish each from the other two.

In the possession of such a variety of attributes as attach to these three classes of bodies, glycocoll is without example in chemistry.

---

* Liebig's Annalen, Bd. lix, s. 292.

### *Constitution of Hippuric Acid.*

It has long been observed that in the preparation of hippuric acid, if the heat be too high or the evaporation too rapid, benzoic acid alone is obtained.*

If it be treated with sulphuric acid and peroxyd of manganese, carbonic acid is evolved, benzoic acid crystallizes from the hot filtered solution, and in the filtrate from the crystals sulphate of ammonia is formed.†

Berzelius‡ has remarked that sulphuric acid may be considered as a compound of benzoic acid and a body of this constitution:—

$$C_4\,H_4\,NO_3.$$

Pelouze had attempted to prove that hippuric acid consisted of one atom of hydrocyanic acid, one of oil of bitter almonds, and one of formic acid:

| | | | | | |
|---|---|---|---|---|---|
| Hydrocyanic acid | = | $C_2$ | $H$ | $N$ | . . |
| Hydrobenzoylic acid | = | $C_{14}$ | $H_6$ | . . | $O_2$ |
| Formic acid | = | $C_2$ | $H$ | . . | $O_3$ |
| Hippuric acid | = | $C_{18}$ | $H_8$ | $N$ | $O_5$ |

Fehling§ entertained the view that it consisted of benzamide and fumaric acid.

| | | | | | |
|---|---|---|---|---|---|
| Benzamide | = | $C_{14}$ | $H_7$ | $N$ | $O_2$ |
| Fumaric acid | = | $C_4$ | $H$ | . . | $O_3$ |
| Hippuric acid | = | $C_{18}$ | $H_8$ | $N$ | $O_5$ |

Over all this field of speculation Dessaigne's discovery has thrown the most grateful light.

Hippuric acid contains benzoic acid and glycocoll. With the aid of heat and a strong acid or alkali, the two members may be separated.

$$C_{18}H_9NO_6+HCl+2HO=C_{14}H_5O_3,HO+C_4H_4NO_3,HCl,HO.$$

or $$C_{18}H_9NO_6+KO+HO=C_{14}H_5O_3,KO+C_4H_4NO_3,HO.$$

By treating glycocoll with caustic potash, we obtain, among other products, cyanid of potassium and ammonia. If a stronger acid be applied to the former it yields hydrocyanic acid, which with water falls apart into formic acid and ammonia:

$$C_2NK+3HO+HCl=KCl+NH_3+C_2HO_3.$$

---

* Schwartz, Annalen der Chem. u. Phar., liv, s. 30. Erdmann, Jour. für Practische Chemie, xiii, s. 422. Dumas, by treating hippuric acid with hypochlorous acid, Annales de Chem. et de Phys., lvii, p. 327.

† Berzelius Jahresbericht, 1840, s. 701.

‡ Jahresbericht, 1836, s. 462. In the Bericht for 1831, s. 240, a similar suggestion from a less perfect analysis of hippuric acid, is to be found. It is again repeated in the Bericht for 1840, s. 704.

§ Leibig's Annalen, Bd. xxvi, s. 60.

Glycocoll contains the elements of fumaric acid and ammonia. If the former alone be taken from hippuric acid there remains benzamide.

$$\underbrace{C_{18}\,H_9\,NO_5}_{\text{Hippuric acid.}} - \underbrace{C_4\,HO_3}_{\text{Fumaric acid.}} = \underbrace{C_{14}\,H_7\,NO_2}_{\text{Benzamide.}}.$$

### *Physiological Relations of Glycocoll.*

Ure* observed that when benzoic acid is taken into the alimentary canal, it reappears in the urine as hippuric acid. This at the time startling announcement, has been verified in the most satisfactory manner by Garrod,† by Keller,‡ in the laboratory of Prof. Booth, Philadelphia, and in the Giessen laboratory.

Pettenkofer§ found in the medical examination of the urine of a girl, who suffered from St. Vitus' dance, and ate nothing but apples and bread, an unusually large quantity of hippuric acid. With the return to animal food, the abnormal proportion of this ingredient diminished.

The occurrence of this acid in the urine of horses and cattle, and of men who live chiefly upon vegetable food, is well known.

These facts taken in connexion with the newly developed constitution of hippuric acid, suggest an inquiry that may not be without interest, viz :—

*Are glycocoll and benzoic acid, as such, a part of the tissues of the animal body?—of the albumen, caseine, and fibrine, supplied to it as food? and finally of the corresponding bodies in the seeds and juices of plants.*

1. Braconnot obtained glycocoll by treating glue with sulphuric acid; Mulder and Boussingault by treating glue with caustic potash; and Keller obtained it by treating the tissues or the fluids of the body with benzoic acid.

The group of atoms constituting glycocoll resisted more firmly the destructive action of sulphuric acid and potash with the aid of heat, than the remaining members composing glue. These were for the most part oxydated or consumed.

The albumen, fibrine, and caseine received into, and secreted from the blood, no sooner become parts of the living organism, than they commence their return to the original carbonic acid, ammonia, sulphates, phosphates, water, etc., from which they were derived. They commence oxydation. This, however, does not affect all members of the complex compounds alike. In some instances glycocoll *escapes oxydation*, appearing in the urine

* L'Institut, No. 399, 279, and No. 401, 294. Journal de Pharmacy, xxviii, p. 646.

† Phil. Mag., xx, p. 501.

‡ Pogg. Ann., Bd. lvi, 638. Liebig's Ann., Bd. xliii, s. 108. Central Blatt. 1844, s. 879.

§ Liebig's Ann., Bd. liii, s. 86.

as a member of hippuric acid, as it escaped oxydation with the potash and sulphuric acid.

2. Fumaric acid is present in a great variety of plants.* In asparagine† we have the elements of fumaric acid and ammonia, which with the requisite metamorphosis would become glycocoll.

$$2(NH_3, C_4 HO_3)=C_8 H_8 N_2 O_6=2(C_4 H_4 NO_3).$$

3. Schlieper‡ by treating isinglass with chromic acid, obtained among a variety of products benzoic acid.

It is found frequently in the vegetable kingdom, for example in gum-benzoin.

We have then benzoic acid and glycocoll (asparagine) in the vegetable kingdom, in the tissues of the animal body, and in the form of hippuric acid in the urine.

It remains to be ascertained if they be present in the *animal and vegetable albumen, fibrine, and caseine.*

### *Formation of Uric Acid Concretions.*

Keller observed both urea and uric acid in the urine after the separation of hippuric acid, and therefrom concludes that Ure's suggestion that benzoic acid might be employed to prevent the formation of uric acid concretions, is too hasty.

The following experiment may have in connection with this subject sufficient interest to justify its being recorded.

The morning urine from mixed animal and vegetable diet, was evaporated over a water bath to thick syrup consistence, and tested for glycocoll. Neither in the alcoholic extract, nor in the residue, could a trace be recognized with the oxyd of copper test. Nitric acid gave a precipitate of urea, not, however, in large quantity.

At ten o'clock the next evening, four grammes of glycocoll were dissolved and taken in water. No consciousness of having taken any thing unusual was felt. The next morning urine reacted acid. Its color was the same as that of the previous day. Upon evaporation to syrup consistence, it presented a much larger quantity than before. One portion was supersaturated with concentrated oxalic acid, accurately neutralized with carbonate of soda and extracted with spirits of wine. Another portion was supersaturated with acetate of lead and treated with hydro-sulphuric acid. Upon evaporating to syrup the extract of the first, and the filtrate of the second, and testing both with the oxyd of copper, no trace of glycocoll was discovered. The glycocoll had

---

* If we include malic acid, the number will be greatly increased.
Buchner's Report, Bd. xxxiv, s. 368. Liebig's Ann., Bd. xxxi, s. 241; Bd. xxxviii, s. 257; Bd. li, s. 246.

† Geiger's Mag., xxxv, 42.

‡ Liebig's Annalen, Bd. lviii, s. 1.

then disappeared. In its place were urea and uric acid, both in larger proportion, as compared with the quantities of the previous day.

If we deduct, as has already been shown, half an atom of grape sugar from two atoms of hydrated glycocoll, we obtain urea:—

$$C_8\,H_{10}\,N_2\,O_8 - C_6\,H_6\,O_6 = C_2\,H_4\,N_2\,O_2.$$

It is conceivable that glycocoll should thus divide, and that the sugar should disappear in the products of oxydation.

By treating it with nitric acid, with this view, no such result was obtained. Concentration or dilution, a strong heat or a moderate and long continued heat, gave no urea and no oxalic acid. One of the products is noticed on page 329.

Uric acid (as bibasic) may be contemplated as a cyanurate of glycocoll:—

$$C_{10}\,H_4\,N_4\,O_6 = C_6\,N_3\,O_3, C_4\,H_4\,NO_3.$$

If benzoic acid be capable of withdrawing glycocoll from uric acid, the remaining member, in the presence of water, would furnish the materials for carbonic acid and ammonia:

$$C_6\,N_3\,O_3 + 9HO = 6CO_2 + 3NH_3.$$

No great confidence can be placed in a single result of this description. Still whatever worth it has, seems to support the suggestion of Ure. Uric acid is found where the products of decomposition are too imperfectly oxydated.* Those who suffer from uric acid concretions are principally sedentary persons. Exercise by increasing the supply and furthering the action of oxygen, more perfectly secures the oxydation of the products of decomposition.

Could a part of the products destined to consume oxygen be withdrawn, the usual supply through the lungs might be adequate to the complete oxydation of the remainder, and thus the formation of uric acid concretions be rendered impossible. Glycocoll is one of these products. If united to benzoic acid, a consumer of oxygen is withdrawn from the blood.

A series of experiments upon given diet, with and without benzoic acid, could not fail to solve this important question.

With this investigation, and particularly with the products of decomposition of glycocoll, which so far as here recorded, may be considered rather as qualitative than quantitative, it is our purpose to proceed with as little delay as possible.

*Note.*—It may not be improper to state that Baron Liebig employs his own time and that of his assistants, and the appliances of his private laboratory, in great part, in labors to ascertain methods of cheap and expeditious preparation, that he may spare

* Liebig's Thier Chimie, 2e. Ausg. s. 125.

the time, means, and patience of the young chemists in his school. He brings to bear his vast experience in this most difficult of all chemical labor—the preparation in their purity of chemical substances.

He had been employed six months in finding out a better method than that of Braconnot or Mulder, for obtaining gelatine sugar, when in the winter semestre of 1845–46, I expressed a wish that he would give me, for a change from the labors in which I had been for some months engaged, a crystalline body, whose study would increase my knowledge of organic chemistry. In compliance with this request he gave me some three ounces of exquisitely beautiful transparent prismatic crystals, whose analysis I employed myself immediately in making. He remarked to me of the method of preparation and of some of its properties, and of much more that I could not retain, and I went to the back journals to ascertain what investigation of it had been made; at the same time making repeated analyses of the pure body, its hydrochlorate and anhydrous sulphate.

The result of this labor and a review of Boussingault's analyses, satisfied me that the constitution of the body, combining with acids, bases, and salts, was—

$$C_4\ H_4\ NO_3.$$

When I had come to this conclusion I had not read the article in the Comptes Rendus, containing Dessaigne's discovery, and felt indebted to no one for the constitution of the body.

Gerhardt's suggestion that the body was—

$$C_2\ H_5\ NO_2 = C_4\ H_{10}\ N_2\ O_4 \cdot \tfrac{1}{2}$$

with his annotation, or $C_4\ H_5\ NO_4 \cdot \frac{1}{2}$, according to that of Liebig and Gmelin, I could not reconcile with the analysis of the anhydrous sulphate; and this also came under my eye after my opinion of the constitution had been formed.

Dessaigne had the honor of having made one of the most brilliant of recent discoveries, but he made no analysis. Laurent made an analysis in the wake of Dessaigne's announcement, confirming the suggestion of Dessaigne, that hippuric acid was a compound of benzoic acid and gelatine sugar. The latter however is not *the body*, glycocoll, but its *hydrate*.

After my paper went into the hands of the conductor of Liebig's Annalen, Mulder's paper, giving the constitution as

$$C_8\ H_{10}\ N_2\ O_8$$

in Erdmann and Marchand's Journal, appeared. This however was not the body, but its *hydrate* doubled.

ART. XXVI.—*Singular Property of Caoutchouc, illustrating the value of Latent Heat in giving Elasticity to solid bodies, and the distinct functions in this respect of latent and free or sensible heat;* by CHARLES G. PAGE, M.D., Prof. Chem. National Medical College, Washington, D. C.

THE fact is familiar that if a strip of India rubber is forcibly stretched, it becomes quite hot from the development of latent heat, owing to the compression which the particles undergo in one direction, by distention in another; and on suffering the strip to relapse, the heat thus developed is absorbed or becomes latent, and the strip appears with its original degree of sensible heat. While thus much has been known nearly as long as the article caoutchouc has been in common use, yet I believe no special observations have been made upon this point, and the following interesting fact, first noticed by me about ten years ago, has excited no particular attention. If when the strip of rubber is in the stretched condition, it be quickly cooled, which can be readily done by wetting it, and evaporating the moisture by vibrating or moving it rapidly in the air, it will be found to have lost its elasticity, and may be left for an indefinite time without regaining its elastic property. It resembles a piece of frozen rubber in some respects, although not quite so rigid. A piece of this substance, which has become stiff and inelastic by exposure to a a great degree of cold soon regains its elasticity by immersion in an atmosphere of 70° Fahr., or even much below this. But the rubber deprived of its latent heat by compression, I have kept in an atmosphere of 80°, for several weeks, without its returning to its normal condition. If the heat be raised much above 80°, or if it be placed in contact with a good conductor at 80°, it gradually recovers its latent heat, and in a few minutes is restored to its original dimensions. A curious sensation is experienced if it be inclosed in the hand, like the creeping of an insect. If successive portions of the inelastic strip be pinched between the thumb and finger, it contracts powerfully in these parts, leaving the others unaffected, and presenting the appearance—as in the figure—of a string of knots or beads, which may be preserved in this state for any length of time, if not handled, and kept at a moderate temperature. Upon examination by a sensitive thermometer, the portions *a* and *b* are found to be of the same temperature. As regards the amount of heat contained, the portions *a* and *b* differ considerably, and in respect to latent heat, *a* may be said to be positive and *b* negative. The junction of the two portions continues abrupt and well defined, as

seen in the figure, showing that there is no tendency to distribution or equilibrium of latent heat between the two portions. When the inelastic strip is inclosed in the hand, a slight degree of coolness is felt from the rapid absorption of heat.

I have been led to revive these interesting facts, in consequence of a recent observation of the difference, in this respect, between the native and the artificial rubber. The artificial rubber is at present prepared in two ways; first, by solution in turpentine and subsequent drying, and chiefly now without the aid of any solvents, by merely grinding the native rubber to a pasty mass, and reducing it to thin sheets between a succession of heated rollers.* In both of these preparations, the peculiarity of the native rubber, above noticed, is hardly perceptible. It is somewhat remarkable that the interesting substance, gutta percha, appears very much like the India rubber when rendered inelastic as above, or by exposure to cold. This valuable modification of caoutchouc, gives according to Dr. Maclagan, by ultimate analysis, carbon 86·36, hydrogen 12·15; and caoutchouc, according to Faraday, gives carbon 87·2, and hydrogen 12·8. The gutta percha yields by destructive distillation similar products to caoutchouc. Like caoutchouc it is soluble in coal naphtha, in caoutchoucine, and in ether, and insoluble in water and alcohol. "Its most remarkable and distinctive peculiarity, as stated by Dr. Maclagan in his communication to the Scottish Society of Arts, is the effect of heat upon it. When placed in water at 110°, no effect is produced upon it, except that it receives the impression of the nail more readily; but when the temperature is raised to 145° or upwards, it gradually becomes so soft and pliant, as to be capable of being moulded into any form, or of being rolled out into long pieces or flat plates. When in the soft state, it possesses all the elasticity of common India rubber, but it does not retain this property long. It soon begins again to grow hard, and in a short time, varying according to the temperature and the size of the piece operated upon, regains its original hardness and rigidity." May not this be a case of isomerism, in which the different arrangement of atoms determines these physical distinctions? The specific heat of gutta percha, I presume, has not yet been determined, but it would be interesting to compare the two substances in this respect.

August 31st, 1847.

* During the operation of rolling, great quantities of electricity are developed.

ART. XXVII.—*Caricography;* by Prof. C. DEWEY, M.D.

(Continued from Vol. iii, ii Ser., p. 356.)

No. 213. *C. intermedia*, Good. Schk., No. 18, Tab. B, fig. 7.

Spicis androgynis distigmaticis ovatis confertis alternis, superioribus et inferioribus pistilliferis vel rarò superne staminiferis, intermediis staminiferis perrarò diœcis; bracteis ovato-lanceolatis; fructibus ovatis rostratis bidentatis convexo-concavis margine ciliato-serratis vel serrulatis, squama ovata acuta paulo longioribus; culmis erectis inferne foliatis.

Culm 12–18 inches high, triquetrous, leafy towards the base, rough on edges above; leaves linear, flat, striate, rarely as long as the culm; spikelets many, ovate, clustered, alternate, the highest and lowest pistillate with often a few staminate florets at the apex, the intermediate often wholly staminate, and sometimes all the spikelets staminate entirely or the plants diœcious; stigmas two; fruit ovate, rostrate, serrulate on the margin, convex on the upper side and concave on the lower; pistillate scale ovate, acute, a little longer than the fruit.

Common in the north of Europe, and by some considered a variety of *C. arenaria;* first recognized in the plants of Arctic America by Dr. Boott; lately found in Wisconsin by I. A. Lapham, Esq. The fruit of *C. arenaria*, L., is broader, less lanceolate. From *C. Sartwellii*, Dew., which has also lately been found by Dr. Cooley in Mich., this is clearly different.

No. 214. *C. maritima*, Vahl. Schk, Tab. W, fig. 74.

Spicis staminiferis 1–3 cylindraceis sub-pendulis cum squamis ovatis longo-aristatis; spicis pistilliferis 1–3 cylindraceis *distigmaticis* bracteatis recurvatis; fructibus suborbiculatis brevi-rostratis vel apiculatis ore emarginatis nervosis, squama ovata oblonga acuta aristata vel emarginata aristata brevioribus.

Culm 10–18 inches high, erect, triquetrous, leafy towards the base; bracts long and leafy, scarcely sheathing; staminate spikes commonly two or more, with ovate and awned scales; pistillate spikes 1–3, cylindric, close jointed, pendulous, and the peduncles scarcely sheathed at the base; stigmas two; fruit ovate, roundish, compressed, obtuse, apiculate or very short beaked, nerved; pistillate scale ovate, acute and awned, or oblong emarginate and long awned, longer that the fruit.

Common in Norway. Found by *Mr. Drummond* at Hudson's Bay and Cumberland House, (Boott,) and by *Dr. Richardson.* (Torrey.)

No. 215. *C. salina*, Wahl. Schk. Tab. Cccc, fig. 185.

Spicis staminiferis 1–2 erectis cylindraceis, inferiori sessili; spicis pistilliferis 2–3 cylindraceis erectis subdistantibus brevi-pedunculatis bracteatis densifloris *distigmaticis;* fructibus ellipticis brevi-apiculatis utrinque convexis ore integris, squama oblonga acuta brevi-aristata brevioribus.

Culm 8–16 inches, leafy towards the base, with long and leafy bracts often undulate at their origin; staminate spikes about two, erect, oblong, with oblong and obtuse scales or varying to lanceolate, the lower one often with some fruit; pistillate spikes 2–3, erect, cylindric, scarcely sheathed at base, rather close-fruited; stigmas two; fruit ovate or elliptic, roundish, short-apiculate or rostrate, convex on both sides; pistillate scale ovate, oblong, acute, short-awned and longer than the fruit.

Found in Arctic America by *Beechy* and *Drummond*, (Boott,) and common on the shores of Norway.

No. 216. *C. aperta*, Boott. Boott in Hook., Fl. Bor. Am., No. 82, Tab. 219.

Spicis staminiferis, 1–2, cylindraceis erectis; spicis pistilliferis, 2–4, *distigmaticis* oblongis supernè approximatis cylindraceis sessilibus apice staminiferis, inferiore subremota pedunculata; fructibus ovatis orbiculatis stipitatis brevi-rostratis ore bidentatis, squama acuta lanceolata brevioribus.

Culm 12–18 inches high, erect, triquetrous, rough on the edges, with sheathing leaves towards the root which are shorter than the culm; bracts leafy below and auriculate; staminate spikes 1–2, long, cylindric, lower sessile, with obtuse darkish scales; pistillate spikes two to four, oblong, erect, close-fruited, approximate above, often staminate at their apex, and the lowest rather remote and pedunculate; stigmas two; fruit roundish, short apiculate, or rostrate, stipitate, bidentate; pistillate scale lanceolate, acute, larger and much narrower than the fruit.

Found at Columbia river by *Douglas* and at Columbia river by *Richardson*,—Boott. Resembles one form of *C. cespitosa*, but appears different.

No. 217. *C. glareosa*, Wahl. Schk. Tab. Aaa, fig. 97.

Spica terminali androgyna inferne staminifera oblonga pedunculata; spicis pistilliferis binis (1–2) oblongis sessilibus approximatis distigmaticis densifloris; fructibus oblongis acuminatis ore integris nervosis convexis, squamam ovatam acutam paulo superantibus.

Culm 6–10 inches high, smooth, triquetrous, leafy at base; leaves linear lanceolate much shorter than the culm; spikes 2–3, ovate, oblong, upper one staminate below and with staminate

scale ovate and oblong and acutish; pistillate spikes 1–2, approximate and sessile; stigmas two; fruit ovate-oblong, acuminate, slightly nerved, convex above, and longer than its ovate and acute scale.

Found in Greenland by Horneman, (Boott,) and not uncommon in Norway.

No. 218. *C. elongata*, L. Schk. Tab. G, fig. 25.

Spica composita; spicis 6–12, ovatis oblongis subsessilibus subapproximatis *distigmaticis* inferne staminiferis erectis subdensifloris; fructibus ovatis tereti-acutis convexis ore brevi-dentatis vel subintegris, margine subscabris, subpatulis, squama ovata obtusa longioribus.

Culm 12–20 inches high, erect, leafy below, triquetrous and scabrous; leaves linear often surpassing the culm; spikelets numerous, six to twelve, ovate, oblong, sub-remotish, nearly sessile, staminate at the base; fruit ovate, acute or long acuminate, convex, fine serrulate on the edge, nearly entire at the orifice or slightly toothed, slightly diverging; pistillate scale ovate and obtuse, about half as long as the fruit; plant yellowish-green.

Found in Russian America by Bongard, (Boott,) and common in Europe.

No. 219. *C. Heleonastes*, L. Schk. Tab. Ti, fig. 97.

Spicis subquaternis ovato-globosis sessilibus confertis inferne staminiferis; fructibus ovatis acutis convexis subbidentatis subpatulis vix margine serrulatis, squamam ovatam oblongam obtusam vix superantibus.

Culm near a foot high, erect, with linear leaves about half as long as the culm; spikelets 3–4, ovate, sessile, approximate, staminate at their base; stigmas two; fruit ovate, acute, convex, compressed, slightly two-toothed, some diverging, very slightly scabrous on the edge; pistillate scale ovate and oblong, obtuse, or sometimes slightly apiculate, a little shorter than the fruit; plant light green.

Found in Arctic America by *Drummond and Richardson*, Boott; and common in the marshes of Sweden.

Dr. Boott refers *C. Carltoniana*, D., to this plant, and if that had more than one androgynous spike, the reference would be correct. C. Carltoniana seems very diverse from the other, and far remote from the figure of *C. Heleonastes*, Schk.

No. 220. *C. amplifolia*, Boott. In Hook. Flor. Bor. Am., No. 158, Tab. 226.

Spica staminifera solitaria perlongo-cylindracea longo-pedunculata; spicis pistilliferis *tristigmaticis* longo-cylindraceis distantibus foliaceo-bracteatis; fructibus ovato-lanceolatis rostratis biden-

tatis, squamam lanceo-aristatam multo superantibus; foliis latis longisque.

Culm two feet high, scabrous-triquetrous; leaves long and broad in the middle and much shorter at the root and smaller; bracts long and leafy, scarcely sheathing; one staminate spike, very long, and pecundulate, with brown and lanceolate scales; pistillate spikes 4–5, long cylindric, loose-flowered, erect, highest sessile, all remote, pedunculate; pistillate scale lanceolate, and the lower long and rough awned, about twice as long as the first.

Found at Columbia River by *Douglass*,—Boott. This splendid Carex is indeed *amply furnished with leaves.*

No. 221. *C. paradoxa*, Willd. Schk. Tab. E, fig. 21.

Spiculis superne staminiferis ovatis oblongis arctè ramoso-paniculatis, ramis inferioribus subremotis, superne aggregatis; fructibus *distigmaticis* ovatis subrotundis convexis compressis teretiacutis vel rostratis bidentatis margine serrulatis, squamam ovatam oblongam acutiusculam sub-æquantibus.; culmo subtriquetro scabro inferne foliaceo.

This species, not uncommon in wet places in Germany, and found by Dr. Richardson in Arctic America, is closely related to *C. paniculata*, L. It differs in being a smaller plant, and much less branching-paniculate, and its fruit is less broadly ovate and lengthened into a beak, while its scale is less broad and less acute.

No. 222. *C. nardina*, Fries.—*C. Hepburnii*, Boott in Hook. Fl. Bor. Am., No. 6, Tab. 207.

Spica solitaria androgyna apice staminifera ovata *distigmatica;* fructibus ovatis vel ellipticis acuminatis compressis brevi-bidentatis margine scabris, squamam ovato-oblongam sub-æquantibus; foliis setaceis hispidis culmum brevem æquantibus.

Culm 3–5 inches high, with rough setaceous leaves sheathing the base and long as the culm; staminate flowers 3–4 at the apex of the spike with narrow lanceolate scales; stigmas two; fruit ovate, acuminate, acutish, convex, compressed; pistillate scale oblong, broad, about as long as the fruit.

Found on the Rocky Mts. by *Drummond*—Boott.

No. 223. *C. Pyrenaica*, Wahl.

Spica unica androgyna apice staminifera *tristigmatica* oblonga per-densiflora; fructibus numerosis angusto-oblongis conico-triquetris brevi-rostratis divergentibus, squamam ovatam oblongam vix superantibus.

Culm 3–5 inches high, triquetrous, with leaves towards the base linear and flat and nearly as long as the culm; spike single, ovate and oblong, tapering above, at the summit staminate, with

lanceolate staminate scales; stigmas three; fruit numerous, oblong, tapering or lanceolate, short rostrate, diverging; pistillate scale oblong, acutish, nearly equalling the fruit.

Inhabits the Pyrenees, and was found on the Rocky Mountains by *Drummond*,—Torry and Boott. The plant from the Pyrenees has rather smaller spikes and other parts. Schk. refers *C. Pyrenaica* to his *C. spicata;* but *C. spicata*, Schk., Tab. D, fig. 15, seems to be *C. Pyrenaica*, Wahl., var. *acutissima* as given by Persoon, on which the flowers are erect and often chiefly staminate.

No. 224. *C. æstivalis*, Curtis. Gray, Am. J. of Sci., xlii, 28.

Spica terminali androgyna superne stamenifera pedunculata cum squamis numerosis staminiferis oblongis subobtusis; spicis pistilliferis 2–4 gracili-cylindraceis suberectis laxifloris bracteatis, infima pedunculata inferne distanti-flora; fructibus *tristigmaticis* elliptico-triquetris utrinque teretibus ore integris glabris, squama ovata obtusa sæpe mucronata longioribus.

Culm 16–24 inches high, slender, triquetrous, leafy towards the base: leaves linear, flat, pubescent, nearly equalling the culm; bracts leafy, long at the lower spikes, scarcely sheathing; spikes 3–5, slender, cylindric, suberect, the terminal spike androgynous with numerous staminate flowers below; pistillate spikes sessile except the lowest, which has remote fruit at the lower part; stigmas three; fruit ellipsoid and slightly tapering to each end, slightly nerved; pistillate scale ovate, obtuse, sometimes acutish or with a mucronate point, shorter than the fruit; grows in tufts.

Found on the Mountains of North Carolina, by Rev. M. A. Curtis of Hillsboro', and named from its long period of flowering in July and August. Its resemblance to *C. gracillima*, Schr., was early pointed out by its accurate discoverer, and its difference also noticed, and as finely by Dr. Gray. It belongs in the same group as *C. virescens*.

*Note.*—In the Transactions of the Lin. Soc., England, for 1845–6, Dr. Boott described *fifty new* or rare species of Carex. Among them is *C. comosa*, Boott, which had in the United States been placed under *C. pseudo-cyperus*, L., from its near resemblance and unwillingness to multiply species, and thus had been the plant described as the Linnæan species, as it was also more common and more striking. The differences have long been remarked; and Mr. Elliott, in his plants of South Carolina, named it *C. furcata*, Ell. As that specific name had already been appropriated, Dr. Boott has described it under *C. comosa*. This form was described in this Journal, Vol. xi, p. 71, under the Linnæan name. Omitting the references there made, the

correct reading would be, No. 36, *C. comosa*, Boott. As the plant of Linnæus also inhabits our country, it becomes necessary to give its characters and distinguish it from *C. comosa*, Boott.

No. 225. *C. pseudo-cyperus*, L. Schk. Tab. Mm, fig. 102.

Spica staminifera solitaria longo-cylindracea erecta pedunculata bracteata; spicis pistilliferis subternis cylindraceis densifloris (immaturis suberectis) pedunculatis pendulis *tristigmaticis*, superioribus subapproximatis, infima distanti longo-pedunculata subvaginata, omnibus foliaceo-bracteatis; fructibus divergentibus demum retroflexis ovato-lanceolatis brevi-stipitatis rostratis nervosis ore bidentatis vel brevi-furcatis, squamam ovato-lanceolatam scabro-aristatam paulo superantibus.

Culm two feet high, sharp-triquetrous, very rough on the edges; leaves linear, flat, nerved, rough, longer than the culm; bracts long and leafy, the lower especially longer than the culm and more or less sheathing; staminate spike single, bracteate, with long lanceolate, hispid-awned scales; pistillate spikes 2–4, long-cylindric, long pedunculate, suberect when young, at length recurved and pendulous, the lowest distant and longer pedunculate; stigmas three; fruit ovate, lanceolate, rostrate, nerved, diverging and finally reflexed, bidentate or with diverging forks; pistillate scale ovate lanceolate, rough awned, and scarcely equalling the fruit; bright green, in tufts on the borders of ponds and streams.

On the specimens of this species from England and Germany, the scales are shorter than the fruit, contrary to the figure of Schk. and most of the descriptions, and the teeth of the fruit vary also, as on our plant, from short and straight to longer and some diverging or furcate.

*C. comosa*, Boott, has larger and thicker stem, leaves and spikes; fruit longer rostrate and more stipitate; and the teeth or forks are longer, deeper, much spreading and partially recurved, producing a *hairy* or *comose* appearance. Its staminate spike not unfrequently has some fruit at its apex. It is a more common plant, though not very abundant. When compared, the two are readily distinguished by the fruit, though so much alike in very many characters.

N. B. The Carex, Vol. xlix, p. 48, should be *C. Tuckermani*, Boott.

*Note.*—As several species of Carex, which have been described as having stigmas 2 or 3, have been found to be different species, it is probable that more extended observations will prove all such to be different species which have a different number of stigmas, as they differ in the form of the seed or achenium.

Additional specimens have thrown much light on the following species.

*C. Woodii*, D. Vol. ii, ii Ser., p. 249.—*C. tetanica*, Muh., (not of Schk.)

With all his accuracy, Muh. confounded *C. plantaginea* and *C. anceps;* described as *C. conoidea*, a plant distinct from that species of Schk. already figured by the latter; and gave *C. tetanica* to a species very different from the description and figure of Schk., Tab. Oooo, fig. 207, which was also described in this Journal, Vol. xi, p. 312. Hence *C. tetanica*, Muh., must have another name, and I have given to it that of *C. Woodii*, clearly the plant of Muh., and as certainly not *C. tetanica*, Schk. Dr. Wood speaks of it as erect, bright green, slender, a foot to twenty inches high, growing singly or not in tufts, presenting a beautiful appearance, culm obtusely triquetrous, and having fruit in maturity frequently open and oblique at the orifice. It needs only to be added that Muh. himself doubted, as well he might, whether his plant was identical with the plant of Schk., as it clearly is not.

*C. tetanica*, Schk., has obovate fruit, with a short but distinct recurved beak, of the *lock-jaw* kind, as its name implies, and the surface is distinctly scabrous or short hirsute, with an ovate, short acute scale, the lower ones often mucronate, the upper ones of the form given by Schk., Tab. Oooo, fig. 207. The fruit of *C. Woodii* has no such beak as is given by Schk. to his *C. tetanica*, and is glabrous, growing on two pistillate spikes, sometimes one or three. It has undoubtedly been confounded with a narrow leafed *C. anceps*, though it differs so greatly from it in several respects.

No. 226. *C. oligocarpa*, Schk.

Spica staminifera unica pedunculata cum squamis oblongis obtusis; spicis pistilliferis subternis (2–4) 3–6-floris laxis distantibus tristigmaticis, superiore sessili, inferioribus pedunculatis brevi-vaginatis; fructibus subrotundo-triquetris obovatis rostellatis ore integris glabris, squama ovata oblonga mucronata subduplo-longioribus.

Culm a foot or more high, decumbent, slender, sometimes nearly prostrate in maturity, triquetrous, smooth, with short, nearly radical and lanceolate leaves; bracts leafy, lanceolate, about equalling the culm with short sheaths; staminate spike single, slender, without a bract, and having oblong and obtuse scales; stigmas three; pistillate spikes 2–4, usually three, with 3–6 fruit, distant, loose-flowered, upper one sessile, and the lower short pedunculate; fruit obovate, roundish three-sided, short rostrate or alternate, smooth, at the orifice entire; pistillate scale ovate, ob-

long, mucronate, white and membranous on the edges, shorter than the fruit; plant fine green.

The striking resemblance of this plant to the figure and language of Schk. is obvious. The difference also between it and *C. Hitchcockiana* is manifest. It is not at all pubescent, and the fruit of *C. Hitchcockiana* is much longer on plants of equal size, much longer and more conic rostrate, more terete at both ends, and when its beak is recurved the form is wholly different from this, and its scale and mucronate point long as the fruit. A sight of the two dissipates all notions of their identity or very close resemblance, though one form of it has been thus misplaced.

But *C. oligocarpa*, Muh., is not this plant. *That* was described Vol. x, p. 280, on the authority of Muh. as the *C. oligocarpa*, Schk., and which has for some years been known as *C. digitalis*, Willd., and its var. *C. Van Vleckii*, and of which *C. digitalis, Muh.*, is probably only a peculiar form. The description of Muh. does not accord with *C. oligocarpa*, Schk. The mistake about *C. oligocarpa*, Schk., the source of much difficulty in relation to some others, is now rectified.

---

## Art. XXVIII.—*On the Action of Sulphuretted Hydrogen upon Nitric Acetene;* by T. S. Hunt.

In my communication of May 29th,* on the relations between glycocoll and alkargene, I stated that nitric acetene (the hyponitrite of oxyd of ethyle of Liebig) is decomposed by sulphuretted hydrogen with the separation of sulphur, and suggested that from analogy we might expect the formation of a new alkaloid, which from the known tendency in bodies of the acetic series to polymorphosis† might be derived from the elements of two equivalents of the ether, and possess the composition $C_8 H_{12} N_2 O_2$, having the same relation to glycocoll that alkarsine has to alkar-

* See this Journal, ii Ser., vol. iv, p. 266.

† M. Gerhardt has proposed to designate by the following terms the four kinds of metamorphosis which embrace all the chemical transformations of organic bodies. 1st. *Symmorphosis;* this includes those reactions which consist in the direct addition or fixation of another substance, as the combination of the alkaloids with acids and of chlorine with certain hydrocarbons. 2d. *Apomorphosis;* this denotes such changes as are produced by the subtraction or elimination of certain elements; thus salts of ammonia lose the elements of water and become amids, and acids in the same manner yield anhydrids. 3d. *Polymorphosis;* this represents a multiplication or combination of two or more equivalents of a compound. Thus three atoms of aldehyde unite to produce a new isomeric body, and under the influence of ammonia, three equivalents of benzoilol coalesce to form with it, one of hydrobenzamid. 4th. *Diamorphosis;* this implies a division or breaking up of a compound into simpler forms, as when an equivalent of cyanuric acid is resolved by heat into three of cyanic acid; or glucose under the influence of certain ferments, into carbonic acid gas and alcohol.

gene. Although my subsequent experiments have not verified this conjecture, they have led to the discovery of a new reaction which is not without interest.

The ether employed in the following experiment was prepared after Liebig's method, by passing the nitrous vapors, evolved by the action of nitric acid upon starch, into a carefully cooled mixture of alcohol and water, and condensing the volatile product in a tube surrounded by ice. It was washed two or three times with water and finally dried by chlorid of calcium. Thus prepared it had all the characters assigned by Liebig to the pure ether.

I. An alcoholic solution of the ether mixed with a little water of ammonia, was placed in a tubulated retort surrounded by ice and connected with a condensing apparatus. A slow current of sulphuretted hydrogen was now passed through the liquid which assumed a dark orange color and almost immediately began to deposit sulphur. Considerable heat was evolved and a portion of the ether distilled over unchanged. When the separation of the sulphur had ceased, and the deep yellow fluid gave evidence of the presence of hydrosulphuret of ammonia, a solution of the ether was added in small portions, until the mixture no longer discolored the salts of lead. It was now carefully neutralized by dilute sulphuric acid and distilled in a water-bath to one half. The residue in the retort was carefully examined and was found to be simply sulphate of ammonia. The alcoholic distillate had a slightly alliaceous odor like mercaptan. In one experiment, operating upon ether, probably impure, a liquid was obtained, with a powerful taste and odor recalling that of garlic.

II. About fifty grains of the ether were introduced into a glass globe and a stream of pure moist sulphuretted hydrogen was conducted to the bottom. The globe was immediately filled with a white cloud and the sides were soon coated with pure sulphur, which was precipitated in such abundance as to make the liquid at the bottom quite thick. When the reaction was finished, the contents of the globe were washed out with a little water; the liquid was alkaline to tumeric paper. A little hydrochloric acid was added, the liquid boiled, filtered, mixed with a solution of chlorid of platinum and evaporated to dryness in a water-bath. The residue washed with alcohol, left a quantity of yellow salt, which, under a magnifier, presented the form of brilliant octahedrons which were readily recognized as the ammonio-chlorid of platinum.

III. These trials led to the conclusion that the reaction resulted in the complete decomposition of the nitric acetene into ammonia and alcohol, and the following experiments placed this beyond a doubt. Having ascertained that the alkaline sulphurets and hydrosulphurets effected this decomposition, a solution of twenty grains of hydrate of soda was saturated with sulphuret-

ted hydrogen. This was mixed with about two ounces of dilute alcohol and 300 grains of the ether, and the solution being carefully cooled by ice, a slow current of sulphuretted hydrogen was passed through until the decomposition was completed. An alcoholic solution of the ether was then carefully added to decompose the excess of the gas in the solution; it was then separated from the precipitated sulphur and neutralized by dilute sulphuric acid. The liquid gave an abundant yellow crystalline precipitate with chlorid of platinum and contained a large quantity of sulphate of ammonia, besides which, nothing but the salt of soda could be detected.

IV. *A dilute solution* of hydrosulphuret of ammonia was placed in a strong bottle with a well ground stopper, and cooled by a bath of ice and water. A small portion of the ether was then added, and the bottle immediately closed. The reaction was violent, and owing to the great volatility of the ether, it was necessary to confine the stopper; when the action was finished, another portion was introduced, until by successive additions of hydrosulphuret of ammonia, 250 grains were decomposed. The clear liquid was then separated from the precipitated sulphur, neutralized by dilute sulphuric acid, and agitated with oxyd of lead to remove the excess of sulphuretted hydrogen, it was then submitted to distillation in a water-bath until about 200 grains of liquid had passed over. This had the smell and taste of dilute spirit of wine; when warmed with a mixture of bichromate of potash and sulphuric acid, the latter was readily reduced with the evolution of aldehyde, which was at once recognized by its odor.

In this reaction one equivalent of nitric acetene and six of sulphuretted hydrogen yield one of alcohol, one of ammonia, two of water, and six of sulphur:—

$$C_4\,H_5\,NO_4 + 6HS = C_4\,H_6\,O_2 + NH_3 + 2HO + 6S.$$

As M. Laurent has lately confirmed the observations of M. Gerhardt, that nitric acetene is produced by the action of nitric acid upon brucine, we are enabled by this reaction to form alcohol by a new process, independent of the fermentation of glucose and from a compound much higher in the organic scale.

The nitric ether of wood-spirit, *nitromethol*, is also decomposed by hydrosulphuret of ammonia, although less rapidly than the nitric acetene; crystals of sulphur separate, and the liquid contains a volatile compound of a powerfully alliaceous odor, resembling that of mercaptan. I have not been able to examine it farther.

P. S. Since the above was written, I have received the Journal de Pharmacie et de Chemie, from which I learn that M. Emile Kopp has already investigated the action of sulphuretted hydrogen upon nitric acetene, and has arrived at the same result as my-

self. But as the remarks in my last communication (p. 266) require some explanation, I here publish my results, and an account of the processes employed. M. Kopp has also shown that the nitric ether (nitrate of oxyd of ethyle of Liebig) is decomposed in a similar manner by hydrosulphuret of ammonia with the production of ammonia and sulphur-alcohol or mercaptan.

Montreal, July, 1847.

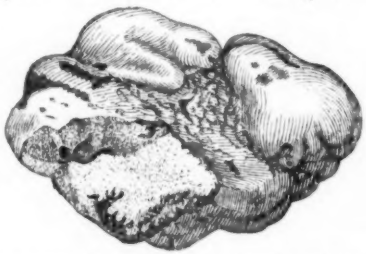
---

ART. XXIX.—*Description of a Meteoric Stone which fell in Concord, New Hampshire, in October*, 1846; by Prof. B. SILLIMAN, Jr.

MY attention was called to this remarkable body by Mr. Abiel Chandler of Concord, N. H., who, in October, 1846, sent me some small fragments of it in a letter, requesting an opinion on its character, and stating the fact that J. S. Noyes, Esq. of that place, was witness to its fall and had retained the meteorite in his possession up to that time. The fragments sent by Mr. Chandler so little resembled, in physical character, any meteoric body which I had before seen, that a letter of particular inquiry was addressed to Mr. Noyes through Mr. Chandler, calling for all the circumstances of the fall and asking the privilege of examining the specimen in his possession. I received in reply, a letter from Mr. Noyes, from which I will make some extracts. The letter is dated Concord, New Hampshire, Oct. 19, 1846. After describing the isolated position of his house on a sandy plain, he goes on to say: "Some time in the month of October, 1840, about two hours after sunset on a bright starry evening, I stood in the road, south of my house some six rods, with my arm resting upon the fence, and facing the southwest, gazing at the stars. Whilst looking up almost perpendicularly, I saw a star, or fireball, fall a considerable distance and then become extinct. Some little time after, I heard a noise in the air, such as a falling body would make, and immediately after I saw a small body strike upon the top board of the fence, about fifteen feet before me, and glance into the road some six feet, then bounding and rolling along several feet farther. I immediately commenced a search, stooping down and feeling in the grass around where I last saw it. After some little search, I picked up the substance in my possession and carried it into the house and examined it. Its appearance being different from what I expected, caused me to make sure by visiting the spot early on the following morning and giving it a further search, the result of which was I found not the least movable substance in the place of its fall. From the circumstance here narrated, I came to the conclusion that I had obtained the body which fell, and that it had a connection with the star

described above. I am well aware that it is an easy thing to be deceived, but sure I am that if mistaken in this instance, no man will be able to undeceive me. The pieces which broke out by the fall I gave to Rev. William H. Ryder, now of Nashua, N. H., about three years since. I have often exhibited the stone and related the manner by which I became possessed of it. There has never been any published account of it." * * * *

Accompanying this letter, I received the specimen in question, which if a meteorite, (as I have now no doubt,) can claim the distinction of being one of the smallest of these celestial fragments, which has yet reached our earth. The accompanying figure is a correct delineation and of the exact size. Some small fragments have been detached but the main portion weighs only 370½ grains.



*Physical Description.*—Its external surface is every where glazed with a brilliant enamel of a grayish white, with occasional patches of deep brown metallic stains. The glazing is found also on the cracked and broken surfaces which penetrate deeply into the mass. The interior is scoriaceous like the frit produced by the partial fusion of feldspar, blown up with extremely minute vesicles and occasional larger bubbles. The porous character of the mass rendered it impossible to procure a satisfactory determination of its density. Its hardness is about 6·5, and it easily scratches feldspar. The larger part of this stone is quite white in color and the fracture has a vitreous lustre. It has no dark colored crust, similar to that which is so characteristic of most meteoric stones, which is owing to the absence of metallic oxyds in its composition, the surface enamel which has been already mentioned, being for this reason without color, excepting in a few spots. The whole stone bears every mark of having been intensely heated. The portions which have the iron stain, are small, and the most careful search with a powerful eye-glass detected no metallic points; nor did the magnet attract the minutest particles.

*The blowpipe* indicated the presence of silica, soda and magnesia. It dissolved in carbonate of soda with effervescence, forming a glass which was nearly opake on cooling. Alone in platinum forceps it fused on the edges, and emitted a phosphorescent light, while the flame beyond the mineral was colored of a clear soda yellow. In a close tube no escape of water or empyreumatic odor was perceived, and the mineral was unchanged by heat. The bead produced by its fusion alone in the platinum forceps, was a clear and bubbly one, which had no metallic stain.

*Chemical Composition.*—So little of the mineral was at my disposition without breaking the principal mass, that no other qualitative examination was made than that with the blowpipe, and this was the less important from the fact, that the pyrognostic characters were so decisive as to the absence of all metallic oxyds. All the fragments which could be found were carefully ground in the diamond mortar and then in agate, and 390 millegrammes of this powder were attacked by hydrofluoric acid, after the manner recommended by Bunsen. When it was judged that all the silica had been removed as hydrofluo-silicic acid, the residue was dissolved in hydrochloric acid in the same platinum vessel in which the attack was made by hydrofluoric acid. The absence of alumina, iron, phosphoric acid, lime, &c., was easily ascertained by the want of any reaction with ammonia and oxalate of ammonia, which failed to produce any troubling in the solution after addition of a sufficient quantity of chlorid of ammonium.

Oxyd of mercury was next added to the boiling and concentrated solution, which was subsequently evaporated to dryness, ignited to expel the mercury, treated with pure hot water, and the magnesia, separated in this manner, from the double chlorid of magnesium and mercury, was collected on a filter and weighed ·0471 millegrammes.

The filtrate from the magnesia, which contained nothing but alkaline chlorids, was evaporated in a platinum vessel of known weight, and their quantity determined by the increase of weight observed on repeated trials, with a constant result. The alkaline residue had the taste only of chlorid of sodium, it was dissolved and treated with bichlorid of platinum, evaporated on a water-bath to dryness, and treated with alcohol. No double chlorid of potassium and platinum was obtained, and the consequent purity of the chlorid of sodium was inferred. The amount of chlorid of sodium obtained was equivalent to ·0106 mm. of soda.

The weight of the meteorite employed = ·390 grms. We have found,—

| | | |
|---|---|---|
| Magnesia, . . . | ·0471 or | 12·076 per cent. |
| Soda, . . . . | ·0106 " | 2·718 " |

Now the known composition of tersilicate of magnesia $\dot{M}g\,3\ddot{S}i$, is, magnesia 12·98, and silica 87·02 per cent. = 100. And the composition of simple silicate of soda, $\dot{N}a+2\ddot{S}i$, is, of soda 40·37, and of silica 59·63 per cent. = 100.

Then 12·98 : 87·02 : : 12·076 : 80·959 = the silica requisite to form a tersilicate with the magnesia :

And 40·37 : 59·63 : : 2·718 : 4·014 the silica needed to form a simple silicate with the soda.

We have then—

| | | |
|---|---|---|
| Silica 3 atoms, . . . | 80·959 | |
| Magnesia 1 atom, . . . | 12·076 | |
| Tersilicate of magnesia, . . | | 93·035 |
| Silica 1 atom, . . . | 4·014 | |
| Soda 1 " . . . . | 2·718 | |
| Silicate of magnesia, . . | | 6·732 |
| Per cent. . . . . | | 99·767 |

Or stating the analysis in the usual form we have—

| | |
|---|---|
| Silica, . . . . . | 84·973 |
| Magnesia, . . . . . | 12·076 |
| Soda, . . . . . | 2·218 |
| | 99·767 |
| Loss and hygrometric moisture, . | 0·233 |
| | 100·000 |

This gives as the formula, $\dot{Mg}\,\ddot{Si}^3 + \dot{Na}\,\ddot{Si}$, which is unlike that of any known mineral of terrestrial origin, but which approaches the composition assigned by Prof. C. U. Shepard to a mineral first observed by him in the meteoric stone from Bishopville in South Carolina, and which he states,* "is a tersilicate of magnesia." For this mineral Prof. Shepard has proposed the name of *Chladnite*. It is believed that the mineral now under consideration is identical with that in the Bishopville stone, and should therefore be called by the same name. The analysis above given was commenced by myself, but being called away from home before its completion, I entrusted it to my friend and pupil, Mr. B. W. Bull of Hartford, to carry through, which he did in a very satisfactory manner.

In conclusion I would say that the chemical constitution of the body under consideration, in connection with the very satisfactory testimony of Mr. Noyes as to its falling from the atmosphere, as already described in the introduction to this article, leaves no doubt in the mind of the writer, that it is a meteorite.

Yale College Laboratory, July 24, 1847.

* This Journal, ii Ser., vol. i, p. 381.

ART. XXX.—*Remarks on the Characters of several Species of Tertiary Corals from the United States, in reply to Mr. Dana.** (Extracted from a letter from W. LONSDALE, Esq. to C. LYELL, Esq.)

Kynsham near Bath, June 21st, 1847.

*My Dear Lyell*,—I am much indebted to you for sending me additional specimens of *Endopachys Maclurii*. They have been carefully considered; but they have not led to a change in the printed opinion; which is perhaps too briefly expressed. It states that, "the Alabama coral was progressively altered in aspect, by the development of tubercles, secreted through foramina connected with the internal structure." (Geol. Journ., Vol i, p. 514.) This remark refers especially to a difference between Endopachys and typical species of Turbinolia, in which no foramina had been noticed in the walls, nor any external changes: but in the generic characters of Endopachys, the boundary wall is said to be "progressively thickened by papillæ secreted from within," (515,) and in a note the generic name is shown to have been proposed in allusion to a "thickening from within." If you will kindly examine the specimens marked 1 and 2 from Claiborne, Alabama, the uppermost portions will be found to be externally imperfect, and in parts, least liable to abrasion, being protected by the bold ridges.† The structure in those portions of No. 1, is highly reticulated and there is apparently a perfect connection throughout by means of circular openings or foramina. These cancelli were evidently occupied with animal matter, which was intimately connected with the soft internal living structures; and which, it is believed, secreted the solid calcareous reticulations. In No. 2, the analogous portions are in a more advanced state externally, that condition having, it is inferred, been effected by secretions from the same animal tissues as built up the inner part of the fabric—the foramina, which are now distinct, having been the channels through which nourishment and calcareous matter were supplied *from within*. The beautiful sections of No. 2, are supposed to support the original inference. In the upper part, the channels leading from the interior outwards, are very numerous: but in the lower, they are less abundant, the exterior having been perfected and the want of such passages diminished.

Certain structural agreements between Endopachys and Dendrophyllia are alluded to in the notice,‡ though from the manner

* Silliman's Journal, ii ser., vol. i, p. 220.
† Consult also wood-cut, fig. *a*, p. 514, and specific characters.
‡ Geological Journal, vol. i, p. 514, 515.

in which Mr. Dana mentions an agreement, a reader would infer that I had totally overlooked them. In *Dendrophyllia ramea*, a certain but limited connexion apparently exists, for a time at least, between the animal matter which occupies the interior of a stem or branch, and that which invests it. The great thickening of the coral, however, is effected by means of the mantle which covers the exterior and forms more or less concentric layers. This mantle often extends also over portions of an adjacent branch, which had, apparently, been deprived of vitality, and deposits additional layers on that branch. In such cases, there could be no connexion between the mantle and interior of the encrusted branch. This process Mr. Dana expressly alludes to in p. 385 of his work. No concentric depositions are visible in the sections of specimens No. 2, and it was with reference to the successive layers formed on the surface of Dendrophyllia by the external mantle; and the evidence in the Alabama coral of a totally different operation, that the term Endopachys was adopted, certain structural agreements having been shown to exist between the two genera.

I hope this explanation if clear will vindicate me from having inconsiderately named your coral.

*Madrepora tubulata*, Mr. Dana says, "is an Oculina," p. 221. Your specimens had only twelve lamellæ.* Oculinæ have more than twelve. Madreporæ have only twelve. This structural distinction is very generally accepted. Internally the American coral agreed far more closely with Madrepora than Oculina, so far as its state of preservation warranted an opinion. The chief objection to the generic assignment is in the mode of developing additional abdominal cavities, and this was felt at the time; but not mentioned because I was not certain that that process was universal throughout the genus. Mr. Dana in his work, p. 486, received long after the notice was printed, describes three species of Madrepora, in which the normal process is apparently deviated from. On this, however, I would not for a moment rest as a justification. I named the coral after a careful examination of the imperfect evidence before me, and placed it in the newest, allied, established genus, the specimens not justifying the proposing a new genus. The reply to the critic might be: It is not an Oculina.

*Columnaria? sexradiata.*—The note of interrogation should not have been omitted by Mr. Dana. It is stated† that the fossil is allied to *Astræa calicularis*, and Mr. Dana in his description of the latter, refers to Esper, pl. 16, Fig. 12. The coral there represented, is generically if not specifically allied to the fine zoophyte you kindly gave me, and is labelled "Caryophyllia—from Lieut. Holland, Prince's Island, west coast of Africa."

* See notice, Geological Journal, vol. i, p. 520.
† Silliman's Journal, p. 221.

*Astræa calicularis*, (auct.) is found in the Mediterranean. If I am right in identifying Esper's figure with the African specimen, generically, and I have no doubt there is no agreement whatever between *Astræa* or *Astroitis calicularis* and the American fossil, every essential character being different, except that the additional stellated cavities are in the *Columnaria? sexradiata* interstitial, but even in this respect, there are many important differences—Mr. Dana should have thought a little more, or given fuller grounds for dissent.

*Astræa hirto-lamellata?* (it must be for the future, *Astræa Marylandica*, Conrad.) This fossil is said to be closely allied to the preceding. (Query, Col? sexradiata? or *Astroitis* calicularis?) In the notice of the fossil* allusion is made to a subdivided star, and though the statement is cautiously put, I had little doubt at the time of the inference being correct. That process is one of the leading characters of *Astræa* as rightly restricted by Ehrenberg, and it is totally wanting in Columnaria? or Astroitis. Of Mr. Dana's Pleiadia no full account has, I believe, been published.

I have troubled you with a long letter of personal justification, but it is due to yourself to shew, that I did not abuse the trust you kindly committed to my care.

---

ART. XXXI.—*Observations in reply to Mr. Lonsdale's "Remarks;"* by JAMES D. DANA.

THE ordinary coral Zoophytes have been so imperfectly studied in a zoological point of view, that no discredit whatever can properly attach to errors of judgment in the cultivators of this department of science. This is especially true with regard to Mr. Lonsdale, whose labors evince throughout, careful and assiduous study of the best authorities in this branch of science, and a success well worthy the honor conferred on him by the Geological Society of London.

The suggestions in the volume of this Journal referred to by him, made by me after protracted researches among living species of zoophytes, were thrown out to promote the interests of science, and if erroneous, will be as readily retracted, and for the same purpose. But several facts are believed to sustain my former conclusions which I will endeavor to explain.

*Genus Endopachys.*—The pores or foramina described as characterizing this genus, I have observed in the *Dendrophyllia nigrescens*,† (D.) from the Feejees, and also still more perfectly in the *D. scabrosa*,‡ (D.) closely resembling specimens I have seen

* Geological Journal, vol. i, p. 500.
† Report on Zoophytes, p. 387. ‡ Ib. p. 390.

of the Endopachys. This character according to my observations, is one of the least important among corals. In Astræa, Pocillopora as well as Dendrophyllia, (and also other genera,) there is every variety in this character, from the most solid, to the most cellular texture. The same species at times is full of pores in the early state and becomes quite solid in a more advanced condition.

From the manner in which the coral is secreted, it is also obvious that the character cannot be important. The secretions take place among the tissues, beneath the skin. They are sometimes so general as to form a solid texture without visible pores, and in other cases, where certain of the animal fibres do not add to the secretions, there are pores larger or smaller, occupied by these animal tissues. These tissues form a communication between the interior and exterior; they occur in the most compact coral, though not visible except in thinly polished fragments examined with a lens, or after digestion in an acid which removes the calcareous material. After the coral is begun in the young animal, it is constantly receiving addition to its surface. A common mode, illustrated in the species of the genera Madrepora, Dendrophyllia and others, consists *first* in the secretion taking place in points, so as to raise minute prominences on the surface; and *next*, after the points are more or less elongated, the secretion becomes more general, and all the points are connected by the calcareous secretions, which thus make a net-work or layer, over the whole. In a transverse section of most Madrepores, the successive series of minute columns are well shown. In the Dendrophyllias referred to, and even in some specimens of the *D. ramea*, the same structure is apparent. When the points are obsolete, the coral will consist of layers of lime, as is sometimes apparent. Often again there is no regularity or approach to layers in the porous structure, as in *D. scabrosa*, &c.

As the animals grow, the pores which contain living fibres in the young state, often gradually diminish by the secretions from the surface of these fibres, which themselves are gradually disappearing, and the coral which was before very porous may finally become solid. Almost every genus illustrates this point. The exterior fleshy part of the animal is in no sense "a mantle," (any more than the skin of an Actinia,) and it is not known ever to extend itself over a part once dead.

If Mr. Lonsdale means simply by "thickening from within," that nourishment and calcareous material are distributed outward from the visceral cavity, (which I suppose is not precisely his view,) then his character will apply to nearly all coral zoophytes; for all cellular coral species have free circulation of the chyloid fluids wherever there are tissues, and these fluids are derived from the stomach and visceral cavity; and the invisible fibres of the more solid species may also have this function; whether so or not, the character is of little importance.

There seems therefore to be reason for dissenting from Mr. Lonsdale, as to the importance of the characteristic upon which he has established his genus.

*Madrepora tubulata.*—The genus Madrepora, characterized by an apical polyp to each branch, graduates into Manopora (D.), when the distinction of apical polyp is lost. The latter are foliaceous and glomerate species having the cell of the Madreporæ in every particular, but with irregular calicles or none; they include the species of the genus *Montipora* of Blainville, based on the existence of warty prominences over the corallum between the cells, (a character without importance and of impracticable application:) and also a part of the *Porites* of Lamark, (*Porites spumosa*, &c.) And as the transition is very gradual there are intermediate species, two or three of which I have referred to Madrepora, since they have regular calicles although the apical polyp cannot be distinguished.* But the structure of Oculina is in no respect represented or approximated to. Indeed the mode of budding of this genus, allies it more nearly to the Astræa family, in which certain branching species show the alternate gemmation at apex characterizing Oculina. Hence the species referred to is far removed from Madrepora; and if it be not an Oculina (by having but twelve lamellæ, and twelve tentacles to the polyps) it must either belong to a new genus, or else the characters of Oculina should be so extended as to include it. I have been long convinced that the number 12, has been allowed too much authority, and have so far infringed upon it in my treatise on Zoophytes as to unite the genera Porites and Goniopora into a single family.

But from Mr. Lonsdale's figure, it is evident that the animal had normally more than 12 tentacles, and that the lamellæ are but 12 in number because part are obsolete. The striæ around the cell are a more correct indication of the character of the animal, than the lamellæ alone.

*Columnaria? sexradiata*, (L.) *Astræa hirto-lamellata*, (Mich.) —These species are still more ambiguous cases, about which there may be an honorable difference of opinion. Having examined the corals referred to, I came to the conclusion, which I still hold, that in one essential character, the species are rather allied to the Caryophyllia family, than the Astræa; notwithstand-

* It is interesting to trace the transitions between these genera. In Madrepora, the horizontally growing species, form a series, in which the branches are more and more coalescent, till at last they form a solid plate, (*M. palmata*,) whose edges only here and there show the tips of the branches of which it is composed. The next step beyond this, is an absence wholly of the branchlets, and the species is a *simple leaf or folium growing at margin*. In all known species, when this step is reached, the calicles are very imperfect or wanting, and they are *Manoporæ*. In the same manner other Madreporæ pass into species with stout branches, in which the terminal polyp is hardly distinguishable (*M cuneata* and the allied); and the next step is a *glomerate Manopora*. Thus there are two lines of gradation from *Madrepora* into *Manopora*.

ing the structure of the coral. As in conchology, the calcareous secretions sometimes may entirely mislead.

The *Astræa calicularis*, and other species figured by Quoy and Gaymard, in the Voyage of the Astrolabe, are closely like Astræas in their corals. Yet the polyps are very prominent above the coral when expanded, each very much projecting, and attached to the adjoining *only at base*. They are like the Gonioporæ in this respect. An Astræa increases by a lateral summit growth and budding, the summit gradually extending, and at the same time forming young polyps as buds. When the polyps are connected only at base, as in the *A. calicularis*, the budding is lateral from near the base and not terminal, and the species are therefore excluded by this characteristic from the Astræa family, and most strikingly from the genus Astræa. From an examination of a recent coral on the coast, very near the Astræa Marylandica of Conrad, I have been led to refer the whole to a group characterized by exsert polyps. The correctness of this reference cannot be fully established until the animals of the recent species are known; and I have waited for an opportunity to make the examination before describing it.

In this species, and also in specimens of *A. Marylandica*, examined by the writer, the polyps do not appear to bud by subdivisions.

The relation of the species designated by Mr. Lonsdale *Columnaria* (?) *sexradiata*, to the genus Columnaria, is only in mode of growth and not in structure.

---

ART. XXXII.—*Notice of a Water-Spout;* by ELIAS LOOMIS.

ON Friday morning, Aug. 20th, 1847, it was my good fortune to witness a water-spout in unusual perfection. I left Erie, Penn., in a steamboat for Cleveland, Ohio, about seven o'clock, with a pretty fresh breeze from the west southwest. The sky was for the most part clear; but there were numerous floating clouds, and in particular one dark mass of clouds arose in the west affording some indications of a shower. These clouds passed nearly over our boat, but brought us no rain. As they moved off to the east, about half past eight, an imperfect water-spout was seen, in the form of a funnel-shaped cloud, suspended from the base of the black mass already mentioned. It bore some resemblance to an elephant's trunk, and curved downward towards the south. It appeared dangling in the air, and terminated at a distance from the water about equal to the length of the trunk. No particular agitation of the water was noticed beneath it. In a few minutes it had disappeared; but presently a second spout was noticed which

attained to great perfection. This also might be compared to an elephant's trunk, reaching entirely down to the surface of the water. At the bottom it was quite small, and it expanded pretty uniformly until it united with the mass of clouds above. It was nearly straight, but by no means upright in position; the top inclining about twenty degrees towards the south. Around its base there rose a vapor which had the appearance of smoke, spreading out on all sides, and rising to a height about one-third that of the trunk. This occurred about forty minutes past eight in the morning. In about five minutes the trunk had contracted so that it no longer reached the surface of the water, but was left dangling in the air like the one first seen. It was soon reduced to one half its former length, and the part which remained was expanded somewhat in breadth. It now appeared to have no connection with the water, except that the same smoky appearance was observed beneath it. The trunk continued to contract in length, and in about ten minutes from its first appearance, it was entirely gone. The same smoky appearance rising from the water in this vicinity was noticed about ten minutes afterwards, and was at first suspected to indicate the commencement of a third spout, but no column of cloud was seen connected with it, and it is possible that this was but the remains of the second spout. The wind continued fresh all day, with numerous flying clouds, but although a good watch was maintained, no further spouts were noticed. The clouds were chiefly of that variety called *cumulus*, rising in high massive piles and spreading out at the top like a mushroom.

It is difficult to estimate the dimensions of this spout, on account of the uncertainty with regard to its distance. It was presumed to have been distant about five or six miles from our boat, in which case the length of the column could not have been less than half a mile; its diameter at the top must have been more than twenty rods, and at the bottom about half as great. As the column contracted in length, its diameter at one time must have been nearly forty rods.

The distance of the spout was such that it was impossible to distinguish any clear signs of rotation; but from its analogy with other phenomena, it is presumed to have been a whirlwind, precisely like the little whirls which are so common on land. When a whirl is formed over a bed of sand, the dust is raised in the centre, and presents the appearance of a solid column which travels slowly along with the current in which it is formed. When the whirl passes over a large body of water, the water is raised in the form of spray; and the result is a column of water instead of a column of sand. The quantity of water thus elevated is probably extremely small, the column consisting of little more than dense fog or cloud. In the case just described, the whirl

was of very large dimensions, and rose to the height of the clouds, so that the spray elevated mechanically from the lake, was united with the condensed vapor of the clouds in the same column. The only danger therefore to be apprehended by a vessel from the passage of a water-spout, arises from the whirl, which often exhibits great violence. The whirlwind might prove destructive to a vessel, while the water which it carries with it might be barely sufficient to wet the deck.

---

## Art. XXXIII.—*On Certain Laws of Cohesive Attraction;* by James D. Dana.

Read before the American Association of Geologists and Naturalists, held at Boston, September, 1847.

From the account of cohesive attraction in works on Chemistry, we gather little more than what the term itself implies; and in the higher treatises on Physics, the subject is discussed on general mathematical principles, and mostly without reference to observed facts, excepting those of the most obvious character. This is especially true of the attraction in solidification. I propose to consider what observation teaches on this subject, and would ask the attention of the Association to a brief statement of a series of facts, and to certain obvious inferences from these facts.

The objects to which we appeal for illustration, are the rocks and minerals of the earth, and the ordinary forms of inorganic matter. The grand principle has already been recognized, that solidification and crystallization are the same process. As early as 1807, in the Lectures on Natural Philosophy by the learned Thomas Young,* this philosopher says, after some explanatory remarks, "It appears, therefore, consistent both with reason and experience, to suppose that a crystallization more or less perfect is the universal cause of solidity." Biot in his Précis† recognizes the same principle; and other names favoring this conclusion might be mentioned. The fact is obviously exemplified in nearly every inorganic solid around us. The freezing of water is known to be its crystallization, and snow is crystallized vapor. The coarse-grained structure of bar-iron is correctly called its crystalline structure; for the grains are all formed by the process of crystallization; and in steel we perceive the same texture, and may trace it through varieties, till the grains are too fine to be distinguished. Granite and all igneous rocks are made up of

* Course of Lectures on Natural Philosophy and the Mechanical Arts, by Thomas Young. M D., 2 vols. 4to. London, 1807. Vol. i, p. 628.

† Précis Elementaire de Physique, 2 vols. 8vo. Paris, 1824. Vol. i, p. 18.

crystallized material; and any one familiar with granite can pick out its mineral grains and exhibit their crystalline character; and if granite is crystallized in its intimate texture, so are all aggregate rocks made up of granite material. Indeed a general survey of the inorganic world develops the truth that here the power of crystallization rules, like vitality in the organic kingdoms. A crystalline texture may not always be apparent. This is the case internally with ice, or a fragment of quartz crystal, although there is no doubt that in each of these instances, the forces of crystallization were the cause of solidification. This is also true of the finest grained steel, as just observed, and some basaltic rocks. But we find, from the transitions in structure, that the apparent absence is owing to the extreme minuteness of the grains and the compactness of texture.

If then, crystallization and solidification are properly one and the same process, the laws that govern in crystallization are the laws of cohesive attraction. The science of crystals instead of treating only of certain singular polyhedral forms assumed by minerals, is the study of the fundamental agency by which inorganic matter is governed in its aggregations: and in place of occupying a short chapter in our text-books on physics, and there, as would often seem, in the way or out of place, it should be made to stand prominently forth as embodying and exemplifying some of the widest elemental truths of nature.

Let us then look at the facts, in order to arrive at these laws. Some of the deductions are by no means new. We commence with the simplest principles, in order to present a general view of the subject; and a few familiar facts in crystallography are illustrated with figures, as the subject may interest some who are not acquainted with them.

1. It is, in the first place, an established fact that the different kinds of inorganic matter have each a distinct mode of crystallization. Every species has certain fixed, determinate, angles, which characterize the structure, both of the crystal and the crystalline grains in a compact mass. Galena crystallizes with a cubical structure; and even in a granular mass, this structure may with care be detected by the rectangular cleavages. So in granular limestone, or common white marble, the oblique angles of the grains are precisely those of the perfect crystals of calc spar. As this is a general truth, *these fixed angles, for each species of matter, in some way characterize molecular or cohesive attraction.*

Again: crystals have plane surfaces, and are prisms or allied forms. Now if the attraction acted alike in every direction it would make only spheres; to produce polygonal forms there must, therefore, be specific directions in which the attraction acts more strongly than in others. For a cube or prism, there must be at least three such directions, corresponding with axes in the

form; and if the prism has oblique angles instead of being rectangular, these lines of strongest attraction must have a corresponding obliquity. Hence *the angles referred to, as characterizing cohesive attraction, are angles between certain imaginary lines, or axes, in whose direction the attraction is strongest.*

Again: the crystalline forms in nature are well known to have fundamentally fixed relative dimensions, indicated by the modifications they undergo (producing secondary forms) though not necessarily apparent in the actual proportions of the crystal. Thus a cube, which is equal in its dimensions, shows it in all its modifications; and in a prism, the inequality in the dimensions is as exactly and precisely indicated by its modifications.* The relative dimensions belonging to the fundamental form of a substance, are often therefore easily calculated; and the whole science of crystals is thus based on rigorous mathematical laws.

From these facts we may conclude therefore with respect to solids, that *Cohesive Attraction is characterized by fixed angles, as regards the direction of its action, and by specific relations of force in certain axial directions; and it differs in these particulars for different substances.*†

These facts are the only hints which nature gives us respecting the axial dimensions of molecules. We proceed on the only possible grounds for any conclusion on this point, when we infer that *molecules have corresponding relative dimensions with the crystalline forms, and the same specific angles between the funda-*

---

* A square prism and a cube as presented in nature, may have actually the same dimensions, owing to the distortion of the one or the other. But the fundamental nature of their forms, may, notwithstanding, be obvious to the eye. In the cube (having equal faces and axes) *all* the edges will have similar secondary planes (that is, these planes will be identical in their inclinations to the faces of the cube); in the prism, the secondary planes of the lateral edges will differ in their inclinations from those of the terminal. In the cube, there may be a plane on any edge equally inclined to the faces of the cube. In the prism, the plane on a terminal edge will always be unequally inclined to the including faces; such a plane removes a part of the two including faces, and these parts will in all cases have a definite relation to the height and breadth of the prism. These explanations are sufficient to render the general principle stated, intelligible to those unacquainted with the structure of crystals. Treatises on crystals should be studied for a full exposition of this subject.

† Apparent exceptions to this principle are supposed to exist in the case of glass, tabasheer and some other substances that do not polarize light. They are, however, not necessarily exceptions. For in these substances the molecules are either equiaxal or inequiaxal;—if *inequiaxal*, the solids prove that such molecules, with weak polar forces, may be so irregularly aggregated as to show no polarization; and if their form is *equiaxal*, no rings of polarization are to be expected.

We have no facts to determine the form of the molecules in glass. As glass, (common as well as volcanic,) when slowly cooled, produces a different material, with a different temperature of fusion, it must be a dimorphous or isomerous material, capable of taking two distinct forms, of which glass is one. We cannot, therefore, infer that the molecules of glass are inequiaxal from the forms of the crystallized silicates of an alkali. The rapid cooling, necessary to form glass, is the most unfavorable for an axial arrangement of the particles, even if the polar forces were strong.

*mental axial lines or axes of attraction.* Thus the molecule of a cube must have equal axes, like the cube itself; that of a prism, like axes with the prism in relative dimensions; and if oblique, the axes should have the same degree of obliquity. This statement with regard to molecules is *potentially* true; and in this sense, the only one in which we now speak of molecules at all, it is no hypothesis.

The actual *forms* of molecules constitute another consideration, and one for which we have less precise data. The molecule of a cube may be either a sphere or a cube, as either form would produce a cube by the same mode of aggregation; and that of a prism may be either a similar prism or a spheroid of like dimensions. This is illustrated in the annexed figures 1, 2, 3.

Fig. 1.

Fig. 2.

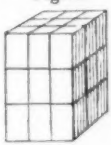


Fig. 3.

We cannot therefore determine absolutely the *form* of the molecule from the form of the crystal. But from the greater simplicity of the hypothesis that molecules are spheres and spheroids, its sufficiency to meet every case in nature, its necessity to explain optical phenomena, and other considerations we have presented elsewhere, we adopt in this place the view of their spheroidal forms.

By having some idea of a molecule in the mind, we may more easily conceive of the principles deduced with regard to cohesive or molecular attraction.

Our first *inference*, expressed with reference to the molecule will therefore be the following:—

I. *Molecules in solids have fixed relative dimensions for each kind of matter, and certain axial lines of cohesive attraction which are fixed in direction*:—and we add, as a necessary truth, *whose force is inversely related to their length.*

Viewing the molecules as spheres and spheroids, the three axes are the three conjugate axes or conjugate diameters of these forms.* The attraction is not supposed to be confined to the

* If the conclusion be correct that the molecule of the *element* gold is a simple *sphere* because of its cubical crystals; and that of sulphur an *ellipsoid*, from the unequal axes of its crystals;—it is as good also with regard to *compounds*. Hence the molecule of pyrites (a compound of sulphur and iron), whose crystal is a cube must be a sphere; and that of alum, a spheroid, &c. It matters not whether we can conceive or not of two molecules of sulphur and one of iron, different in size and shape, uniting so as to make a simple sphere. The conclusion is one not dependent for its truth on our conceptions. The finite mind is an *interpreter* of nature and may not presume to the rank of dictator. Its conceptions will be as inane with regard to any kind of combination or mode of aggregation in the above case, which could produce out of such means a symmetrical cube with its faces similar in lustre and every other physical character.

axes, as these are only imaginary lines of concentration of force; the other parts of the molecule must necessarily have attracting force though to a less amount than along the axial lines.*

The fact that crystals are formed by the superposition of molecules by axial attraction, is a matter of observation. In an evaporating brine we may see the minute cube of salt enlarging without change of form, a fact which implies that ranges of particles are added regularly to each side. In a drop of sea water under the microscope, we may watch the growing crystal of gypsum, and see its rhombic and arrow-head forms as perfect in the smallest visible point, as afterwards when more enlarged; proving again that the particles are added in fixed lines, since in no other way could there be this constancy of angle. It is proved again by finding many instances in calc spar, quartz and other minerals, of crystals with internal layers of another mineral which were deposited on the faces of the crystal during an intermission in their progress; showing the form of the crystal in its earlier stages. Hence we may not doubt the reality of the axial lines of cohesive attraction.

Brewster, in the course of his splendid researches on the optical phenomena of crystals, has shown that in some instances the particles are in a state of tension, as by compression. In a recent article on the topaz,† he describes the occurrence, in certain crystals, of extremely minute cavities, which indicate by means of polarized light, that the parts adjoining have been acted upon by a compressing force. Long since he observed respecting the diamond that its crystals,—which are peculiar in having *convex faces*,—exhibit, as he states, "an imperfect, doubly-refracting structure, as if aggregated by irregular forces, and compressed or

---

* The several axial conditions illustrated in crystals include all the possible variations of the three diameters of spheroids, as is mentioned by the author in an article in this Journal, vol. xxx, 1836, p. 282, and Mineralogy, 2nd edition, p. 79. They are as follows, (using the term *axes* for the diameters having rectangular intersections; and *diameters*, for the diameters having oblique intersections.)

I. *Sphere*—Three conjugate axes; equal, (1.) *Cube.*

II. *Ellipsoid of revolution.*
- A. Three conjugate axes, the two lateral equal, (2.) *Right square prism.*
- B. Three equal conjugate diameters, [with equal oblique angles of intersection,] (3.) *Rhombohedron.*

III. *Ellipsoid, not of revolution.*
- A. Three conjugate axes, unequal, (4.) *Right rectangular prism.*
- B. A vertical axis, and two equal conjugate diameters, (5.) *Right rhombic prism.*
- C. A vertical axis, and two unequal conjugate diameters, (6.) *Right rhomboidal prism.*
- D. Three conjugate diameters, two equal, (7.) *Oblique rhombic prism.*
- E. Three conjugate diameters, unequal, (8.) *Oblique rhomboidal prism.*

† L. E. and D. Phil. Mag., August, 1847, xxxi, 101.

kneaded together like a soft gum or jelly." He concludes from the facts, that the topaz must have been in a soft and plastic state while it yielded to the compressing force which emanated from the cavities, and farther, infers (as in 1805 from his experiments on depolarization) "the existence of a new species of crystallization, which is the effect of time alone, and which is produced by the slow action of corpuscular forces."

If the facts prove a comparatively soft state of the topaz when first formed, as they appear to do, they indicate that the crystal while afterwards hardening, would undergo contraction, in which case such minute cavities or any foreign particle would become apparent centres of a compressing force. The regular form of the topaz crystal, presenting a perfect correspondence in every respect with other crystals, can be explained only on the supposition of axial attraction; and while the necessity of time and corpuscular forces must be admitted, we fail to see evidence of a new species of crystallization. In the diamond, the same principle may have operated. If the crystal when first formed is still imperfectly hardened, contraction would continue for a time in progress; and the contraction in this case acting with some reference to radii from the centre, and affecting most the prominent edges and angles, might give the convex form presented by the faces of the crystals, and the peculiar structure within.

The fact mentioned at the meeting of the British Association in June last, by Mr. H. F. Talbot, that a fused globule of nitrate of potash polarized light, like a regular crystal, only shows that some species may retain the axial forces and arrangement in the fluid state. It is known that certain fluids have the power of polarization. These facts extend instead of limiting our proposition, proving that the molecules of some substances, even in the liquid state, may have the inequiaxal forms, generally detected only in solids.*

---

* Sir David Brewster, after mentioning his grand discoveries with regard to producing the polarizing structure in glass and other substances by tension, suggests that the polarizing structure of crystals arises from the mutual pressure of the elastic particles during crystallization. He concludes that the axes of crystallization are three in number and at right angles to each other, and observes, "that when any two molecules are brought together by the forces or polarities which produce a crystalline arrangement and strongly adhere, they will mutually compress one another, and each will have an axis of double refraction in the direction of the line joining their centres, in the same manner as if they had been compressed by an external force."

The facts are explained, as we believe, more simply and more in accordance with the laws of crystals, by attributing the character of ordinary polarization in crystals to the form of the molecule independent of pressure. The molecule in inequiaxal crystals must be inequiaxal, and this is a sufficient reason, without adding pressure as an additional cause. Pressure at the poles, would only flatten the poles, and this would make an irregular solid of the ellipsoid, inconsistent with the

After these observations, I continue with the statement of facts and the inferences they sustain.

2. In crystals which have unequal axes, the physical qualities of the crystal (such as color, hardness, lustre, &c.) are different in unlike directions; and they are uniformly alike in the direction of equal axes. This symmetrical character indicates that—

II. *In the aggregation of molecules by attraction, only equal or homologous axes unite.*

3. The electrical polarity of many crystals; the occasional dissimilarity of form in the opposite extremities of the same prism; the facts with regard to compound crystals, as well as direct experiments with magnets on the process of crystallization, show that—

III. *The axes of cohesive attraction in molecules have opposite polarity at opposite extremities;*—that is, *the opposite poles are positive and negative, or north and south, as these terms are ordinarily used.**

4. Many geniculated crystals, are geniculated alike at equal distances from the middle of the prism, (or, are like a column bent alike at two places equidistant from the middle.) They have be-

character of the polarization in crystals. The effect of this flattening of the surface of the molecule by pressure is probably seen in the curious crystals of analcime,[a] whose structure has been developed by this distinguished philosopher. In the case of glass and other substances, that receive the power of polarization by pressure, it would seem from the facts just stated, that it depends upon a change by compression of the spherical molecule to a spheroidal or compressed shape; the shape is a result of pressure; but as in crystals, the polarization may be dependent on the shape.

The polarization of molecules will depend not only on their form, but also on their nature, whether uniform in character throughout, or differing in density from the centre to the circumference and with a definite inverse relation to the lengths of unequal axes. As the latter supposition is altogether the most probable, considering that molecules are centres of attraction, the form of the molecule and the form deduced from polarization should not be the same until this law of relation is understood and duly appreciated.

* By polarity we imply simply that relation between the diametrically opposite parts, A and B, of a molecule, by which the part A of one molecule unites to another molecule by the part B, and repels the part A. This property appears to be one of the fundamental qualities of matter or force, as no exhibition of force in nature is divested of it. In solidification this polarity is exerted most strongly along fixed axes.

[a] Crystals of the tesseral system to which analcime belongs, do not polarize light; but in specimens of this mineral, a peculiar system of rings has been detected by Brewster: they suggest at once, that like certain cooled cubes of glass, the structure has arisen from a change of form in the molecules dependent on tension.

come thus geniculated simultaneously at both extremities, while they were enlarging, evincing that—

IV. *The polarity of molecules may be reversed by extrinsic influence.**

5. Twin crystals have one half of the crystal in a reverse position from the other.† This may be imitated by cutting a crystal in halves, and after a semirevolution of one half, applying the parts again together; an oblique crystal will thus have a reëntering angle, as in fig. 5. If in fig. 5, A be the position of the nucleal molecule for one half, B must be that for the other. The mode of aggregation for a simple crystal is that shown in fig. 4. The attraction between the two molecules brought them together in either case. But in one the position of the molecules when about uniting was favorable for the direct union in fig. 4; and in the other, the two were in opposite positions, yet so close in proximity that union took place by the adjacent poles without allowing of the change of position necessary for direct union. In the former, the same poles of the vertical axes, are in the same direction; and in the latter, they are in opposite directions. There could not be such an inversion of the molecules, if the axes were a *result* of the act of union. Hence,—

Fig. 4.

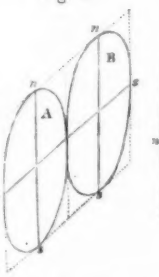
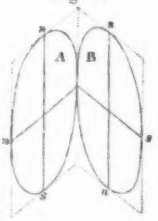



Fig. 5.




V. *The axes and polarity of cohesive attraction in solidification exist before the union of the molecules, instead of being a consequence of that union.*

6. The forms of inequiaxal crystals vary somewhat with a change of temperature; and at certain temperatures, specific in each case, some substances undergo abruptly a total change of form, both as to the direction and relative lengths of the axes. Hence,—

VI. *The axial lines of cohesive attraction, are not indefinitely fixed in position, but are some way modified in direction and force by temperature.*

Thus far we have considered the general polar condition of cohesive attraction in solidification, its liability to a reversion of the

* See an article by the author, in the American Journal of Science, for 1836, vol. xxx, p. 275, and particularly p. 292; also Mineralogy, the chapter on Crystallogeny.

† We consider here but a single kind of twin crystals, in the briefest manner possible, as the facts are sufficient for our deductions. See farther, Amer. Jour. of Science, and Mineralogy, as just referred to.

poles like ordinary magnetic polarity, and its varying in direction with the changes of temperature. There are evidences of other modifications in the condition of the attracting force, which we now consider.

7. The same species of matter often presents a variety of forms in its crystals, built up on a fundamental type. For example, when the type is a cube (fig. 6), the species may occur as cubes; or as cubes with the edges truncated (fig. 7); or with the edges beveled (fig. 8); or with the angles replaced (figs. 9, 10), and so

Fig. 6. Fig. 7. Fig. 8. Fig. 9 Fig. 10.



on. If then a certain state of the attraction in a molecule will produce the primary cube, some variation from this state is necessary to produce another form, and a different variation for every different secondary plane. Consequently,—

VII. *Attraction of cohesion in molecules of a given kind, is not an unchangeable force, but admits of variations of condition.*

8. The secondary planes of crystals, as related to the axes of the fundamental form, have fixed simple ratios. The plane trun-

Fig. 11.

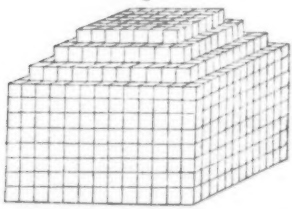
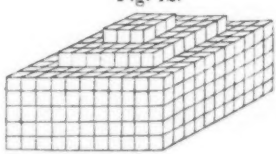
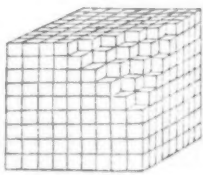


Fig. 12.



cating the edge (fig. 7) referred to the axes, has the simple ratio of 1 : 1 (fig. 11). Other planes (as in fig. 8) may have the ratios 1 : 2 (fig. 12), 1 : 3, 1 : 4, 2 : 3, and other simple ratios. Planes on the angles (figs. 9, 10) referred to the three axes, may have the ratios (indicating their positions) 1 : 1 : 1 (fig. 13), 1 : 2 : 2, 1 : 3 : 3, 1 : 2 : 4, 2 : 3 : 6, 3 : 5 : 15, and so on. Hence,—

Fig. 13.



VIII. *The variations which the attraction of cohesion undergoes, take place according to some simple ratio.*

9. Similar parts of crystals, with a single class of exceptions, are similarly modified. Now as the similar parts are those similarly situated as regards like axes, it follows that—

IX. *The homologous parts of molecules similarly and simultaneously undergo this variation as regards the attraction.*

10. In the excepted cases just alluded to, only half the similar parts are modified alike. In the cube of boracite, only half the angles have similar secondary planes (fig. 15); in pyrites it is usual to find only one of the two beveling planes in fig. 8, on each edge, as in fig. 14; it is an alternate one throughout, so that the form is still symmetrical, and this is uniformly true. The right and left handed quartz are other examples. Consequently,

Fig. 14.

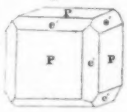
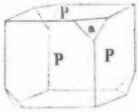



Fig. 15.



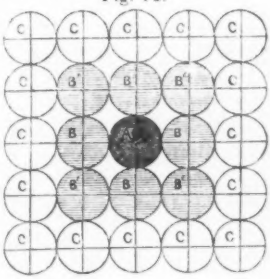

X. *In some cases, the parts of a molecule on opposite sides of a pole undergo a different amount of variation of attraction; this takes place symmetrically with regard to all the poles.*

11. In the formation of a cube with truncated edges, the cube is not finished out on the edges. There is therefore a diminution of the force of attraction in the line of the primary axes, since these axes fail of completing the cube. Hence,—

XI. *If the state of the attraction which produces a primary cube or prism is considered its normal state, when secondary planes are produced there is a decrease of force in the direction of the principal axes, and this decrease is in some simple ratio.*

12. In the enlarging cube, the molecules are added in planes of increasing breadth, as in this way only would the form continue to be a cube. If we consider the case, we find that the central molecule attracts a molecule by each of its poles, and also simultaneously the added molecules act by their lateral axes to complete the plane (fig. 1). We observe in the sectional view (through the centre) in fig. 16, when A by its axes unites with four B's, the B's, simultaneously, while in the act of union, unite with B′, B′, B′, B′; and thus the square form is retained. This is a simple statement of the process.

Fig. 16.



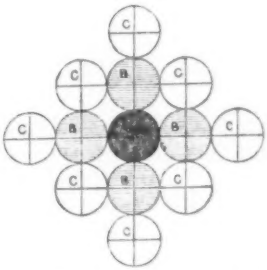

If now when the B's are uniting, their lateral axes do not act at the same time, then the forming cube will have the edges trun-

cated as in fig. 11. To understand this we must study the steps in the process. Fig. 17 represents the same secondary planes as in fig. 11, without the primary faces. It is obvious that in the enlargement of such a secondary, when the summit molecule is annexed, its lateral axes do not act as they do when a cube is formed:

Fig. 17.



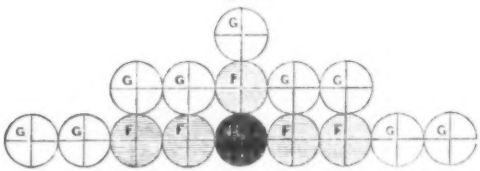
Fig. 18.




when another molecule is added beyond, then they act laterally. This may perhaps be more clearly seen in the transverse section in fig. 18. When A attracts B, B does not act laterally as in fig. 16; it does not so act until B attracts C, when a C is added either side of B. So C acts laterally when a D is added to C, and not before.

Again in fig. 19, we have a section of another figure, (the same secondary as in fig. 12,) showing the arrangement of molecules in a solid, presenting such a section. Examining it, we perceive

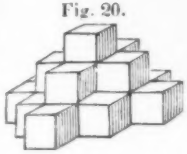
Fig. 19.




that when G is added to the extremity of the central axis, two molecules, G, G, are added on either side of F, and none laterally to G. This figure represents the formation of the secondary plane having the ratio 1 : 2, as is evident from inspection, and fig. 17 or 18, another with the ratio 1 : 1.

If the period of time occupied by the union of a molecule be represented by $p$, then when the lateral axes act only after the period of time $p$, and then add a single row of molecules, the secondary plane is the truncating plane 1 : 1; for the plane having the ratio 1 : 2, in which two are added laterally to one terminally, or what is equivalent, one laterally for every half a one terminally, the time would be $\frac{1}{2}p$; for the plane 1 : 3, the time would be $\frac{1}{3}p$.

Fig. 20.



To understand the origin of planes on an angle, we must again consider the actual circumstances. Fig. 20 (the same secondary as in fig. 13) will aid the mind in conceiving of it. Here, when the summit particle unites itself, it adds nothing laterally, as was the case also in fig. 17; when another unites beyond, then four particles are united, one by each lateral pole; but these four add nothing, until still another particle is added to the summit. In this case there is an interval of time $p$, between the action of the terminal and lateral axes, and another interval $p'$, between the adding of the four molecules and the action by *their* lateral axes. And this is the difference between the plane truncating an angle (figs. 9 and 13), and another truncating an edge of a cube, (figs. 7 and 11.) This plane truncating an angle has the ratio 1 : 1 : 1. For a plane 1 : 2 : 2, the times will be each $\frac{1}{2}p$, and for any plane $1 : m : n$, the times will be $\frac{1}{m}p$ and $\frac{1}{n}p'$.

It appears that the lateral axes act less speedily therefore for the truncating plane of an angle, than for that of an edge; the centre of the former in a cube is 54° 44′ from the centre of a face of the cube, and the centre of the latter from the same is 45°.

We have before observed, that the production of secondary forms depends on the fact, that the force of attraction in the axes of the molecules when secondaries are produced, is less than that which is exerted when the primary prism or cube is formed. But we cannot suppose the whole force of attraction in a molecule to be different in different circumstances. No facts nor reasoning would sustain this conclusion. We may admit that the attraction may be more concentrated in the primary axes, in some cases than in others. It is well known that the polar condition in bodies does not imply an addition of force, but simply an axial action or concentration of the force. This concentration or excited action may be induced by the condition of neighboring bodies or influences: and different bodies should differ widely in their susceptibility to it, as is evidently the fact. Now if the attraction is less concentrated in the primary axes, when a secondary plane forms, the *interval of time* above alluded to as characterizing the formation of different secondaries, will be longer or shorter according to the state of concentration in the primary axes. The more or less diffused state of the attraction is connected with the kind of secondary produced.

But when we observe in a complex crystal, the evenness of the faces, the neat regularity of the edges, and the perfection throughout, even when many secondary planes are combined, it appears clear that such forms could not result from simply a generally diffused state of the attraction, any more than a primary could be so produced. In each case there must be as many distinct axes

as there are planes. When therefore the principal axes lose their concentration, this loss consists in a distribution of the force into subordinate axes intermediate between the primary axes. For a truncation of the edges of a cube, the intermediate axes would have their poles just at the middle point between every two poles of the primary axes; for a truncation of the angles, the poles would be at the middle point between every three poles. We have remarked upon the symmetrical arrangement of secondary planes in general, and this would follow from the necessary symmetrical arrangement of such axes. Moreover the length of time $p$, will be greater the farther the secondary pole is situated from the primary poles. And this is true in fact. The pole for the octahedron is the most distant, being at the central point between three primary poles.* The number of combined secondary forms may still seem mysterious. But a crystal, in its capacity as a unit, would necessarily have a corresponding character in its different parts to the molecules of which it consists, and consequently the attraction exerted by the molecules in these different parts would correspond, occasioning thus the secondary planes. Moreover the relative extent of the several different kinds of planes, will depend primarily on the relative force of action in the different sets of axes.

These considerations lead us to conclude, that—

XII. *The diminution of attracting force in the primary axes, on which the formation of a secondary depends, consists in the partial action of this force along intermediate axes, symmetrically situated with reference to the primary axes; and the greater or less amount of diminution, determines the kind of distribution.*†

13. The same crystalline forms, may have different cleavage in the case of different species of matter. Thus, cubes of galena have a cubical cleavage, while cubes of fluor spar have an octahedral cleavage or yield octahedrons when cleaved. In ordinary crystallographic language, the cube is therefore said to be the primary of galena, and the regular octahedron is the primary of fluor spar. These different circumstances would result, provided that in one case (for galena) the three primary axes of the molecule were dominant, and in the other the eight intermediate or octahedral axes. The arrangement of the molecules in each case would depend on the dominant axes, and so also would the direction of the cleavage. Hence,—

* Here is evidently basis for mathematical calculations of some interest.

† In the case of substances that very seldom crystallize or never, we have evidence that the polar forces are very weak. The attractive force may be so diffused as to approximate to the ordinary state in liquids.

XIII. *The direction of cleavage may indicate in any species of matter which set of axes is dominant, the primary, or a secondary set.*

In the preceding paragraphs, after ascertaining the general polar action of cohesive attraction, we have pointed out the modifications of condition this attraction undergoes, the simple ratios presented by these modifications, and their dependence on the formation of intermediate axes. Cohesive attraction instead of being a constant force, as might be inferred from the ordinary definitions, appears therefore to be complex in its actions, yet simple in the general laws by which this complexity is produced.

14. The absence or presence of secondary planes, and their character, are known in some instances to depend on external circumstances. Electric currents, the nature of the supporting rock, or the condition of the solvent are determining causes. A floating crystal has been seen to form secondary planes on becoming attached. Crystallizing in a thick pasty mass as Beudant has observed, will generally afford the simpler forms. The most complex are usually the purest crystals, such as have been produced in the most quiet circumstances. Implanted crystals are sometimes rendered more complex during the last stages of their increase than they were before. These facts show some of the ways by which modifications in the condition of the attraction in the primary axes are produced. The presence of foreign material, sometimes, or whatever may sustain an excited state of polarity in the primary axes, will occasion the formation of simple forms. But if there is nothing to sustain or excite this concentration, or the action is quiet, or if bodies around induce it, owing to their own condition, the attraction becomes more diffused, and secondary axes multiply.* All the crystals of a locality or region have usually the same form. The constancy of certain forms in some species is evidence of the peculiar susceptibilities of the molecules of those substances. Thus the calc spar in the limestone of Lockport has the dog-tooth shape, the scalene dode-

* The theory above offered with regard to the origin of secondary planes, is near that presented in 1839 to the Royal Society, by Prof. Necker. How far they are identical, I cannot decide with certainty from the brief notice of his paper, which I have seen in the Philosophical Magazine, vol. xiv. p. 216. M. Necker supposes that there is a tendency in crystals to take the spheroidal forms of their molecules; that when the secondary axes are destroyed by different causes, simple crystals are produced. According to the view here presented, there is no tendency of this kind recognized; the concentration of the primary axes producing simple forms is the ordinary condition of the molecules of some substances in solidification; and by this concentration, however produced, the secondary axes lose their force. The view I had gathered from the abstract of M. Necker's memoir, is given in a note to page 100 in the author's Mineralogy, 2nd edit., New Haven, 1844.

cahedron; that of Boonville, New York, occurs in short six-sided prisms. That of the Rossie lead region in complex combinations of different secondary planes with the primary.

XIV. These facts indicate, that *the variations of attraction, producing secondary forms, depend often on surrounding bodies favoring the concentration or diffusion of the attracting force; and the causes often act simultaneously in nature over wide areas.*

15. It is also a usual truth, that crystals are sometimes very much lengthened beyond their normal proportions, and in other cases, very much shortened. When attached, they are lengthened or shortened in the direction of the axis of attachment; and if obliquely attached, they are distorted in this direction. These facts, which are of common observation, show that—

XV. In an enlarging crystal, *one axis (or two) may have the action of attraction more accelerated or retarded than another by extrinsic influence, and this acceleration or retardation affects equally all crystals forming together under common circumstances.*

16. The peculiarities of cleavage give us information on another point respecting cohesive attraction. The facility of cleavage in prisms differs in the direction of unlike axes. Topaz cleaves easily parallel to the base of the prism, and not at all in other directions. This difference does not depend upon the relative strength of attraction in the unequal axes; for it is often the reverse of this. Again, while some of the hardest substances have perfect cleavage, other soft species have none.

If then this quality has no relation to the strength of the attraction which unites molecule to molecule, it must depend on some peculiarity in the manner in which this force acts. This force may act in two ways:—either *continuously*, or *intermittedly;* and the latter mode only, could produce the result in view. The action of force in nature appears to be generally intermittent. Alternate action and comparative inaction, with corresponding results, are every where exemplified in organic growth; and it is therefore no anomaly that it should be exemplified in the inorganic kingdom.*

* The successive layers in wood, the periodical reproduction of leaves or flowers, and of young in animals, and the seriate arrangement of parts in many plants and animals all illustrate intermittent growth. In some zoophytes the buds form in successive series of two, four or six, or some other fixed number; in other cases opposite sides alternate in budding, or when there are several rows, the rows bud in succession; and these are examples of intermittent action.

The spiral arrangement of leaves in vegetation, as I have elsewhere observed, (Zooph., p. 80,) is another illustration of intermittent growth; for here the different sides of the growing plant (*five*, in many plants, and *six* in many others) bud

We infer therefore that when cleavage is produced, the union of layers of molecules takes place by an intermitted action; that is, with regular successive variations or pulses in the intensity of the force of attraction. This intermitted action when reduced to simply the adding of single layers in succession, becomes continuous. On these principles there might be every variety of this quality in nature, and there should be no necessary connection between cleavage and strength of attraction. We therefore infer that—

XVI. *The action of cohesive attraction is often intermittent, producing seriate results, (as exemplified in the cleavage of crystals,) and the specific rate of intermittent action is different for unequal axes.**

17. Cohesive attraction may be partly controlled in its results by gravity, and by rate of solidification or of chemical combination. It is evident that in the cooling of a liquid mass, when the temperature of solidification is reached, there will be numberless points throughout the mass where the molecules will commence the process of crystallization; and acting together, they would produce an aggregation of small crowded crystals or grains, with no external regular forms, in other words, the *granular* structure. In cases of a crystallizing solution, the same result may happen, if the process be rapid.

Again, a thin solution spread over a large surface, would produce crowded minute points; and if the solution be gradually supplied, as the crystallization goes on, it is obvious that the minute points crowded together might elongate into crowded prisms,

---

successively, for the simple reason, of universal application, that reproduction produces temporary exhaustion, or, that force is exerted intermittedly.

The *pulsation* of molecular force is also an example of intermitted action, and must lie at the basis of the universal principle on this subject to which we have alluded. The reality of this pulsation, insisted upon by Mr. J. D. Whelpley in 1845 before this Association,[a] and also by Faraday,[b] we cannot doubt. The undulatory theory of light must be received as fully demonstrated: and if it is an ether that pulsates, it is molecular force which makes it pulsate, and this implies pulsating action in molecular force itself.

The attraction of cohesion is shown by cleavage to be intermittent in *intensity*; we do not learn from it that there is any actual intermission of time in the exertion of the force, or a variation in rate of pulsation.

* Many crystals have their surfaces covered with parallel striations which consist of alternations of two or more sets of planes. Thus cubes of pyrites very generally have their faces marked with striæ which are oscillations between a plane replacing the edge, and either the face of the primary cube, or another plane of the same secondary. Some octahedrons of fluor spar have faces which consist of minute cubes. These facts, and they are common and well known, show frequent intermittent mode of action in the different axes of molecules, (or a seeming strife between different sets,) producing what has been called an "oscillatory combination" of planes.

[a] Rep. Proc. for 1845, and also this Jour., xlviii, 352. and ii Ser., ii, 401.

[b] Phil. Mag., May, 1846, and this Jour., ii Ser., ii, 401.

and produce a fibrous structure. Such a structure is common in narrow seams in rocks, proceeding either from this cause, or perhaps in part from the electric influence of the adjoining walls of the seams.

The concentric structure is another result depending on the rate of solidification connected often with the rate of chemical combination. In the first place the nucleus is always a cluster of molecules, instead of a single one as for a simple crystal. The structure sometimes commences around some foreign body as a centre, though the aggregation is often without any proper nucleus, except that of the cluster of molecules that first solidified. The second principle, on which the concentric structure depends, is the tendency of a body to communicate its own condition to other bodies within its influence. This law—the law of equilibrium, and contact, or catalysis in chemistry—is one of the universal laws of existence. According to it, either a collection of molecules entering the solid state, or any foreign body already solid will tend to bring adjacent bodies into the same or an intermediate condition. If susceptible to this influence, the particles adjoining become assimilated, and unite to the nucleus; these again act upon others adjoining, and thus a spherical form is produced, as a result of successive development. In glass that has cooled with extreme slowness, there are often spherical aggregations of crystals. Here, in some single point, the mineral of the aggregation first began to form; and once begun, the process was continued, according to this law of influence, around the point as a centre, and the aggregations are therefore spherical. In cooling basalt or granite, large spherical concretions are often formed. The process of solidifying is in these cases continued through a very long period of time; and from the relation often perceived between the thickness of a bed of basalt and the size of the concretions, this size is evidently greater the slower the cooling. In this prolonged cooling, after a while, here and there a spot reaches the solidifying condition, and the process commences. The particles adjoining, as explained, become solid about the spot; thence the process extends itself equally in every direction; and spheres are the result. The slower the cooling, the longer the time occupied in passing through a single degree of temperature; and consequently, when the cooling is most gradual, the centres would subordinate to themselves a large amount of material, and produce larger concretions.

In other cases, a solution is infiltrating through a clay or sand:—something (it may be a harder point or spot, or some organic object) determines the commencement of solidification at certain points in the clay, and from this, the process continues by simple propagation, as just described. The stratification of the clay, or texture arising from gravity, favoring infiltration laterally more

than vertically, will often cause such concretions to be flat; and when they become very numerous, a bed of concretions is changed to a solid bed of compact rock.

In still other cases, a molecular change of the same general character and on the same principle, goes on after consolidation has taken place.

The structure of such concretions must depend on the material constituting them. The mode of formation, and the general property that attraction has a definite relation to distance from a centre, will give them a similarity of character, in corresponding parts. The constituent crystalline grains, when any are apparent, will have necessarily a corresponding position with reference to the centre. A foliated mineral which in one part had the foliation concentric in the spherical mass, would have for the reason stated, the foliation concentric throughout; and a fibrous mineral, with the fibres radiating from the centre, would retain this structure regularly.*

These considerations sustain the conclusion, that—

XVII. *Cohesive attraction produces spherical concretions, about a cluster of molecules as a nucleus, through the tendency of molecular action or condition to propagate itself; and concentric aggregations begun, act under the general influence of the radial action of attraction in a mass, which action, other things the same, is equal at equal distances from a centre.*

We might consider other effects of cohesive attraction, and extend our remarks to liquids and gases. But this paper has already reached an undesired length, although giving but the outlines of a subject that admits of great extension; and the consideration of liquids and gases in the present state of our knowledge would involve us in speculations that we have purposely endeavored to avoid.

We have thus endeavored to follow out the various facts presented by matter as it exists around us. Observation has proved more profitable than closet speculation in animal and vegetable Physiology; and so it will be with regard to the grand organizing force of the so-called inorganic kingdom,—the basis of Mineral Physiology. The fact that the attraction of molecules is liable to modifications of condition, and especially the simple yet fixed relations between these modifications, nothing but a crystal could make known to us. Yet the principle is as wide as the universe in its application; for we live in a universe of molecules, and all the grandeur of physical nature is the result of molecular forces.

* The concentric structure here explained is analogous in many respects to the circular and spherical forms in vegetation. The growing lichen extends itself circularly, owing to progressive assimilation or development. This proves no similarity of nature between the organic forces and cohesive attraction; it only shows that different forces act under a common law.

Through the preceding pages I have intentionally avoided allusions to the actual nature of molecules, as the conclusions are independent of any views on that subject. Even form and size are not essential to the deductions, as what has been designated the lengths of the axes, may be viewed as the inverse ratio of the attracting force in the axial directions. If the existence of an ether be insisted upon as surrounding the molecules, the relations are none the less correct.

The facts however prove that in the action of cohesive attraction there is a limit to penetrability, fixed in different directions for given temperatures; and this limit is essentially a limit of form and size; and as the phenomena of light are dependent on molecular forces, we cannot deny to molecules color and other qualities of sensible objects.

The ether appealed to in order to explain the phenomena of light,—admitted to have none of the qualities of matter and yet often spoken of as a real existence,—is a kind of machinery, summoned for the sake of an explanation; and since we may now believe that instead of such an ether capable of pulsations, *pulsating molecular force* itself will afford as perfect an explanation of the phenomena of light, the necessity of the ether even as an hypothesis is done away with.* There is therefore no reason from this source for doubting the conclusion that the forms of molecules and their relative dimensions, as ascertained from crystals, are their real forms and relative dimensions.

The phenomena of heat as explained by received theories, seem to present a similar objection to the view we here take, since an ether or a mysterious imponderable agent is supposed to intervene between the molecules in the expansion of solids, and by its arrangement to cause the change of axial directions. But the assumption of this tertium quid gives us no aid in understanding the change of axial direction, and the general law with regard to attraction, on which we must fall back in either case, will be much simpler without it. Neither, as my friend Mr. J. D. Whelpley has argued, is this hypothesis necessary in order to explain expansion. Since molecules may undergo all the various modifications of condition and form which have been pointed out, it is not improbable that they should also admit of change of size. Size is known to be directly related to temperature: every degree of temperature in a given substance is connected with a specific size. To effect a change of size in molecules, attraction, the same which has been shown to vary in concentration and other particulars, must also vary in radial force. The variations which have been pointed out are caused by induction, according

* See note, page 379. This principle, like the theory of gravitation when first presented, rose into view to simplify, just when theoretical science was becoming encumbered with rapidly increasing perplexities.

to the general law of mutual influence, or tendency to equilibrium, and no other law is required to explain a change of size. For if there were in existence molecules of the same substance of different sizes (or in other words of different temperatures), there would be between them a tendency to equilibrium of size (or in common language, to a mean temperature); and thus this simple law of mutual influence will explain enlargement or contraction from variations of temperature; and the variations from a mean size, (a mean temperature,) arrived at when two *different* substances mutually act on one another, will be specific heat. The change of form and axes in molecules dependent on change of temperature, will be a consequence of change of size, according to some law yet unascertained.

This view, for which we are indebted to Mr. Whelpley, explains expansion without recourse to any intervening ether, or any imponderable agent, excepting the general force of attraction. Admitting these conclusions, it will follow that the forms deduced for molecules are their actual forms. We confidently believe it will soon be shown that this change of size and attendant changes in pulsating force, will sufficiently explain the physical effects of heat.*

A *molecule* according to these views, is spherical or spheroidal in form:—

It exerts attraction in every direction; but this force on opposite parts is so related that one molecule attracts another by one side and repels it by the opposite (polarity):—

In solidification (and sometimes before?) this attraction is axially polar; it admits of various degrees of axial concentration or diffusion, (§ 7 to 12,) of acceleration or retardation of action, (§ 15,) and of different degrees of radial force, which variations take place under the general law of mutual influence, or tendency to an equilibrium:—

This attraction acts by pulsations; in solidification there are also compound pulses (undulations in intensity) consisting of a series of pulsations, and producing intermitted or seriate results (cleavage), which results are in all cases specific; the same pulsations (the optic nerve being sensible to them) produce the phenomena of light; they are also a means of producing chemical effects, especially when the pulsations exceed the rapidity of those for light, (the *chemical* rays being those beyond the violet ray or those which have been shown to be most rapid in vibration.) The $\alpha$ and $\beta$ states of elements, or their passive and

* The relations of heat and magnetism, are illustrated in a valuable article in this volume, by Prof. W. A. Norton, pp. 1 and 207; and some following pages contain an interesting memoir on heat and light by Prof. Draper.

active states,—the former changing to the latter under the action of light or the chemical rays,—will be different states induced by or through rapidity of pulsation, the rapid pulsation of molecular force (causing or constituting what we call chemical rays) inducing the same rapid action in molecules under their influence. Magnetism may be a condition in which the attractive force is in constant active onward transfer from particle to particle, and galvanism, a condition of similar transfer while an exciting cause is in operation.

In hemihedral prisms like those of tourmaline and topaz, the molecules must have been in this magnetic condition; for they exhibit polarity now when heated. In the *right* and *left handed quartz* and similar cases, where while forming one side of a molecular pole must have been differently affected from the opposite, we may believe that the pulsations were alternate along each axis, *a*, *b*, *c*; this would in fact be a spiral action and it would produce a right and left handed crystal, according as the spiral action was to the right or left.

We accord in many particulars here stated, with the general theory of molecules and molecular forces presented lately, with some important shades of difference, by Whelpley and Faraday, and based on that of Boscovitch.

The explanations offered show that very many of the phenomena of physical nature, may be understood on the idea that molecules are simply centres of attraction, the same attraction whose laws have been under consideration. But no property of cohesive attraction explains the *limits* and *proportions* observed in chemical combination. The ultimate nature of the molecule, or of the forces constituting them, (on which we forbear from remark in this place,) is our only appeal for an explanation of these chemical relations. When fully understood, it may appear that cohesive attraction with all its laws, is only a necessary result of this peculiar constitution. We need yet some facts to make it obvious how both classes of phenomena, those of aggregation and chemical combination, may be united in one continued series.

These theoretical suggestions on molecules are annexed to the preceding article, partly in elucidation of some facts before stated, but more especially to exhibit the bearing of the principles on different theories respecting the constitution of matter, and to show that what may seem to be discrepancies are not necessarily so.

There is a strange variance between the chemist and crystallographer. In treatises on chemistry, a theory of molecular forms is often presented as the truth in a chapter on crystals, the falsity of which is taken for granted in all the other parts of the work.

Nature with more consistency, points to a unity of truth. This truth cannot be reached through any one avenue of science. Chemistry teaches us the laws of combination governing molecules, and the attendant operations of molecular forces;—crystallography indicates to us the forms of molecules and the laws which govern in molecular aggregation;—the eye being sensible to the movement of molecular force, optics teaches us the rapidity, character, and physical effects of its pulsations:—and we add by our thermoscopic instruments, another sense, for ascertaining other laws of molecular action. When the mind is fully opened to all these several sources of light, their concentrated beams will enable us to see beyond doubt the minute molecule almost with the distinctness of visibility.

---

ART. XXXIV.—*Results of the Examination of several Waters from Hartford, Conn.;* by B. W. BULL.

THE different samples were taken from wells in the city of Hartford, Conn., May 28th, 1847. Their localities are as follows:—

No. 1 is from a well in the State House Yard, northwest corner.

No. 2 is from the well of H. Seymour, 16 Main street.

No. 3 is from a well on the grounds of the American Asylum.

No. 4 is from Lane's Coffee House, North Main street.

No. 5 is from the New England House, Front street.

The soil of Hartford is an alluvium of ferruginous clay, sloping toward the Connecticut River on the east, and overlying the red sandstone of the greater secondary of Connecticut. It is in fact derived entirely from the decomposition of the soft argillaceous and calcareous shales which characterize this part of that deposit. No. 3 is taken from the more elevated portion of the city. No. 1 is from the centre of the city, No. 5 from the eastern, and Nos. 4 and 2 from the northern and southern extremities respectively. The gases contained in the waters were not estimated, as the immediate object of the investigation was to ascertain the amount of solid matter; neither was their action upon lead observed, which would have been interesting if time had allowed, more particularly as the results obtained by Prof. B. Silliman, Jr., in his examination of waters for the city of Boston, show conclusively that the established opinion, that water containing sulphates in solution is without action upon lead, is not sustained by experience.

A peculiarity in all of the waters with the exception of No. 1, is the excess of bases in combination with crenic acid and probably with organic matter in other modifications; an opinion derived from the fact that those portions from which the crenic acid had been separated by neutral acetate of copper, were upon con-

centration and evaporation highly colored, the color disappearing upon ignition. This reaction was observed upon all the samples from which this acid was separated, but a deficiency of material precluded the quantitative estimation of it in all but No. 3, in which the amount was 2·6 grains in one gallon, a quantity not sufficient to saturate the excess of base. The large excess in most of the waters may appear to exceed the bounds of probability, but repeated and concurring experiments show the results to be correct. In the deficiency of knowledge in relation to the modifications in which organic matter exists in combination with bases in water, and the unsatisfactory methods which we possess for its determination, it was preferred to state the results as obtained without attempting to estimate the organic matter with which the excess of bases is supposed to be combined. Its presence was abundantly proved by the action of nitrate of silver in solution upon the specimen under examination.

There were no indications of phosphates, apocrenic acid, or of potassa. The soap test, as might be inferred from a glance at the table, indicates that they possess in an eminent degree the property of *hardness*, becoming, with the exception of No. 3, immediately and perfectly opaque upon the addition of the test to the waters contained in a wine glass, accompanied in Nos. 1 and 5 with the formation of a curdy precipitate occupying nearly half the bulk of the tested liquid. The order of succession, considering No. 3 the best, would be 3, 4, 2, 1, 5.

The following tables are the results of the analyses. Table I. shows the specific weights and the amount of solid contents as found by evaporation and ignition in conjunction with a known weight of pure anhydrous carbonate of soda, added to prevent loss by the decomposition of any chlorid of magnesium; the weight of No. 5 is that found by analysis. The weights and measures used were the French *gramme* and decimals, and the *litre*, but are reduced in the tables to standard Troy grains, and the U. S. gallon of 231 cubic inches, the weight of one gallon distilled water at 60° F. being taken as 58·328,886 grains.

Table II. gives the amount of the constituents as found by actual analysis, without reconstruction. The discrepancy between the footings of this and the next table, arises from the loss of oxygen which the bases undergo by the formation of haloid salts with chlorine.

Table III. In this table the results of the analyses are combined as they may be supposed to exist in the waters in their natural state. The method recommended by Fresenius has been followed in reconstructing them, and the conclusions, though liable to criticism from the well known impossibility of accurately reproducing their original combinations, are supposed not to vary essentially from reality.

Table IV. gives the relative proportion of water and solid contents in 1000 parts.

I would express my indebtedness to Prof. B. Silliman, Jr., for many valuable suggestions during the course of the accompanying analyses.

TABLE I.

| | No. 1. | No. 2. | No. 3. | No. 4. | No. 5. |
|---|---|---|---|---|---|
| Specific weight, | 1·00081 | 1·00044 | 1·00010 | 1·00078 | 1·00106 |
| Amount in grains of solid contents in one gallon, as found by evaporation, | 41·479 | 32·157 | 19·334 | 37·102 | 69·046 |

TABLE II.

*Constituents of one gallon in grains, as found by actual analysis, without reconstruction.*

| | No. 1. | No. 2. | No. 3. | No. 4. | No. 5. |
|---|---|---|---|---|---|
| Chlorine, | 12·765 | 3·563 | 2·407 | 3·517 | 21·557 |
| Sulphuric acid, | 2·296 | 2·114 | 1·028 | 2·710 | 3·061 |
| Carbonic acid, | 6·449 | 3·429 | ·561 | 3·826 | 4·533 |
| Lime, | 12·192 | 7 671 | 7·075 | 8·103 | 10·358 |
| Magnesia, | 1·168 | 1·116 | ·555 | 4·621 | 5·293 |
| Alumina and iron, | ·204 | 2·267 | . . | ·261 | traces. |
| Alumina, | . . | . . | ·817 | . . | . . |
| Soda, | 7·437 | 6·362 | 6·893 | 13·764 | 23·718 |
| Silica, | 1 052 | 3·474 | ·817 | ·261 | ·526 |
| Ammonia, | . . | traces. | . . | . . | . . |
| Nitric acid, | . . | . . | traces. | . . | . . |
| | 43·563 | 29·996 | 20·153 | 37·063 | 69·046 |

TABLE III.

*Contents in one gallon as recombined.*

| | No. 1. | No. 2. | No. 3. | No. 4. | No. 5. |
|---|---|---|---|---|---|
| Sulphate of lime, | 3·902 | 3·538 | 1 744 | 4·606 | 5 208 |
| Chlorid of calcium, | 6·522 | 4·046 | 2·282 | . . | 10·498 |
| Chlorid of sodium, | 11·162 | . . | . . | . . | 15·481 |
| Chlorid of magnesium, | 2·396 | 1·309 | 1·272 | 4·757 | 2·419 |
| Carbonate of lime, | 13·149 | 7·581 | 1·260 | 8 350 | . . |
| Carbonate of magnesia, | 1·109 | . . | . . | . . | 8·815 |
| Alumina and iron, | 0·204 | 2·267 | . . | 0·261 | traces. |
| Alumina, | . . | . . | 0·817 | . . | . . |
| Silica, | 1·052 | 3·474 | ·817 | ·261 | ·522 |
| Carbonate of soda equivalent to crenate of do., | 1·517 | 6·462 | 6·892 | 13·756 | 15·507 |
| Magnesia combined with crenic acid, | . . | 0·783 | . | 2·685 | . . |
| Lime, | . . | . . | 4·481 | 1·336 | . . |
| | 41·043 | 29·506 | 19·565 | 36·012 | 58·450 |

TABLE IV.

*Relative proportions of water and solid constituents in* 1000 *parts.*

| | No. 1. | No. 2. | No. 3. | No. 4. | No. 5. |
|---|---|---|---|---|---|
| Water, | 999·289 | 999·449 | 999·669 | 999·364 | 998·818 |
| Sulphate of lime, | ·069 | ·061 | ·030 | ·079 | ·089 |
| Chlorid of calcium, | ·112 | ·070 | ·039 | . . | ·179 |
| Chlorid of sodium, | ·191 | . . | . . | . . | ·267 |
| Chlorid of magnesium, | ·041 | ·023 | ·022 | ·081 | ·041 |
| Carbonate of lime, | ·225 | ·131 | ·021 | ·148 | . . |
| Carbonate of magnesia, | ·019 | . . | . . | . . | ·151 |
| Alumina and iron, | ·004 | ·038 | . . | ·004 | traces. |
| Alumina, | . . | . . | ·014 | . . | . . |
| Silica, | ·018 | ·060 | ·014 | ·004 | ·010 |
| Carbonate of soda equiv. to crenate, | ·022 | ·109 | ·119 | ·235 | ·267 |
| Magnesia combined with do. | . . | ·013 | ·076 | ·044 | . . |
| Lime, | . . | . . | . . | ·023 | . . |
| Loss, | ·010 | ·046 | excess. | ·018 | ·178 |
| | 1000·000 | 1000·000 | 1000·004 | 1000·000 | 1000·000 |

Yale College Laboratory, New Haven, Aug. 9th, 1847.

---

ART. XXXV.—*On the Production of Light by Heat;* by JOHN WILLIAM DRAPER, M.D., Professor of Chemistry in the University of New York.*

ALTHOUGH the phenomenon of the production of light by all solid bodies, when their temperature is raised to a certain degree, is one of the most familiar in chemistry, no person so far as I know has hitherto attempted a critical investigation of it. The difficulties environing the inquiry are so great, that even among the most eminent philosophers a diversity of opinion has prevailed respecting some of the leading facts. Thus Sir Isaac Newton fixed the temperature at which bodies become self-luminous at 635°, Sir Humphry Davy at 812°, Mr. Wedgwood at 947°, and Mr. Daniell at 980°. As respects the nature of the light emitted there are similar contradictions. In some philosophical works of considerable repute, it is stated that when a solid begins to shine it first emits red and then white rays; in others it is asserted that a mixture of blue and red light is the first that appears.

I have succeeded in escaping or overcoming many of the difficulties of this problem, and have arrived at satisfactory solutions of the main points; and as the experiments now to be described lead to some striking and perhaps unexpected analogies between light and heat, they commend themselves to our attention as having a bearing on the question of the identity of those imponderable principles. It is known that heretofore I have been led

* Extracted from the London, Edinburgh and Dublin Philosophical Magazine, May, 1847.

to believe in the existence of cardinal distinctions, not only between these but also other imponderable agents; and I may therefore state, that when this investigation was first undertaken, it was in the expectation that it would lead to results very different from those which have actually arisen.

The following are the points on which I propose to treat:—

1. To determine the point of incandescence of platinum, and to prove that different bodies become red-hot at the same temperature.

2. To determine the color of the rays emitted by self-luminous bodies at different temperatures. This is done by the only reliable method—analysis by the prism.

From these experiments it will appear, that as the temperature rises the light increases in refrangibility; and making a due allowance for the physiological imperfection of the eye, the true order of the colors is red, orange, yellow, green, blue, indigo, violet.

3. To determine the relation between the brilliancy of the light emitted by a shining body and its temperature.

Here we shall find that the intensity of the light increases far more rapidly than the temperature. For example, platinum at 2600° emits almost forty times as much light as it does at 1900°.

As I prefer to give a complete description of the apparatus employed in these investigations after the general results are stated, it is sufficient here to understand that the source of light is in all instances a very thin strip of platinum 1·35 inch long and $\frac{1}{20}$th of an inch wide, brought to the temperature under investigation by a voltaic current. Platinum was selected from its indisposition to oxydize, and its power of resisting a high temperature without fusion.

The slip of platinum, thus to be brought to different temperatures by an electric current of the proper force, was fastened at one end to an inflexible support, and at the other was connected with a delicate lever-index, which enabled me to determine its expansion and thereby its temperature. For this purpose I have used the coefficient of dilatation of Dulong and Petit. The temperatures here given are upon the hypothesis of the invariability of that coefficient at all thermometric degrees; they are therefore to some extent in error.

By the aid of resisting wires of different length and a rheostat, I was able to vary the force of the electric current in the platinum, and thereby vary its temperature. My first attempts were to discover the point at which the metal begins to emit light.

The platinum and the voltaic battery were placed in a dark room, the temperature of which was 60°; and after I had remained there a sufficient length of time to enable my eyes to be-

come sensible to feeble impressions of light, I caused the current to pass, gradually increasing its force, until the platinum was visible. In several repetitions of this experiment it was uniformly found that the index to which the platinum was attached, stood at the eighth division when this took place. The metal had therefore dilated $\frac{1}{222}$ of its length; the elevation of its temperature was about 917°, which added to the existing height of the thermometer, 60°, gives for the temperature of incandescence 977° F.

To the correctness of the number it may be objected, that owing to the narrowness of the metallic strip it is not well calculated to make an impression on the eye when the light it emits is so feeble; nor can we take the dilatations given by the index, as representing the uniform temperature of the whole platinum, which must necessarily be colder near its points of support, by reason of the conducting power of the metals to which it is attached.

Physiological considerations would also lead us to suspect that the self-luminous temperature must vary with different eyes. The experiments of Bouguer, hereafter to be referred to, indisputably show that some persons are much more sensitive to the impressions of light than others. So far as my limited investigation of this matter has gone, I have not however found appreciable differences in the estimate of the temperature of incandescence. Different individuals, observing the platinum, have uniformly perceived it at the same time.

Against the number 977° it may also be objected, that antimony melts at a much lower temperature, and yet emits light before it fuses. If this statement were true, it would lead us to believe that all bodies have not the same point of incandescence. But I think the experiments of Mr. Wedgwood on gold and earthenware are decisive of that question; and, moreover, I have reason to believe that the melting-point of antimony is much higher than commonly supposed.

With a view of determining directly whether different bodies vary in their point of incandescence, I took a clean gun-barrel, and having closed the touch-hole, exposed the following substances in it to the action of the fire:—platinum, chalk, marble, fluor spar, brass, antimony, gas-carbon, lead; each specimen was small; the platinum was in the form of a coil of stout wire.

When one of these bodies was placed in the gun-barrel and the temperature raised, it is clear that any difference in their point of incandescence would be detected by the eye. Thus, if the ignition of platinum required a higher degree than iron, on looking down the barrel the coil of wire should be dark, when the barrel itself begins to shine; or, if the platinum was incandescent first, the wire should be seen before the barrel is visibly

hot; and these results might be corroborated by observing the inverse phenomena, when the barrel is taken from the fire and suffered to cool.

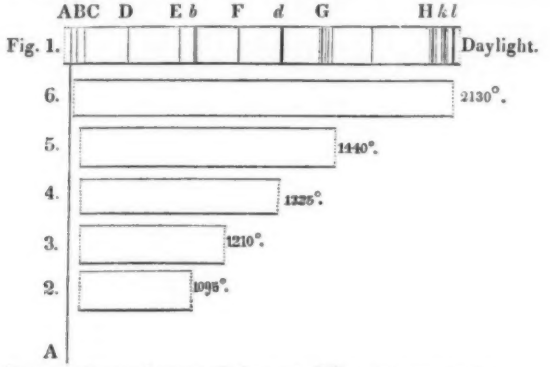
With respect to platinum, brass, antimony, gas-carbon and lead, they all became incandescent at the same time as the iron barrel itself. I could not discover the slightest difference between them, either in heating or cooling; and it is worthy of remark, that the lead was of course in the liquid condition. But the chalk and marble were visible before the barrel was red-hot, emitting a faint white light; and the fluor spar still more strikingly so, its light being of a beautiful blue; and even when the barrel had become bright red I could still see the spar, which had decrepitated to a coarse powder, by its faint blue rays. In these cases it was not, however, incandescence but phosphorescence that was taking place. I infer then that all solids, and probably melted metals, shine at the same thermometric point.

The temperature of incandescence seems to be a natural fixed point for the thermometer; and it is very interesting to remark how nearly this point coincides with 1000° of the Fahrenheit thermometer, when Laplace's coefficient for the dilatation of platinum is used. Upon that coefficient the point of incandescence is 1006° F.

In view of these considerations, and recollecting that the number given by Daniell is 980°, and that of Wedgwood 947°, I believe that 977° is not very far from the true temperature at which solids begin to shine. It is to be understood, of course, that this is in a very dark room.

I pass now to the second proposition. The rays emitted by the incandescent platinum were next received on a flint glass prism, placed so as to give the minimum deviation, and after dispersion viewed in a small telescope. A movement could be given to the telescope, which was read off on an annexed scale. However, instead of bringing the parts of the spectrum under measurement to coincide with the wires stretched across the field of the instrument, I found it more satisfactory to determine them by bringing them to one or other of the edges of the field; a process well adapted to ascertain the position of the extreme rays, the faint light of which contrasted well with the darkness by which it was surrounded. They could not have been so accurately seen while the rest of the spectrum was in view; and as it was absolutely necessary to have fixed points of reference, that all the observations might be brought to a common standard of comparison, and as there are no fixed lines in the light of incandescence, such as are in the sunshine and daylight, I therefore previously determined the position of the fixed lines in a spectrum formed by a ray of reflected daylight which passed through a fissure $\frac{1}{25}$ of an inch wide and one inch long, occupying exactly

the position subsequently to be occupied by the incandescent platinum. Fig. 1. represents the results of this observation.




Spectra of incandescent platinum at different temperatures.

The strip of platinum was now placed in the position of the fissure which had given the spectrum, fig. 1, and its temperature was raised by the passage of a voltaic current. Although I could distinctly see the metal when the heat had reached about 1000° by the naked eye, yet the loss of light in passing the prism and telescope was so great that I found it necessary to carry the temperature to 1210° before a satisfactory observation could be made. At this point the spectrum extended from the position of the fixed line B in the red, almost as far as the line F in the green; the colors present being red, orange, and a tint which may be designated as gray. There was nothing answering to a yellow. The first rays visible through this apparatus may therefore be designated as red and greenish gray; the former commencing at the line B, and the latter continuing to F. The magnitude and other relations of this spectrum are given in fig. 3.

The voltaic current was now increased, and the temperature rose to 1325°. The red end of the spectrum remained nearly as before, but the more refrangible extremity reached to the position of the little fixed line *d*. Traces of the yellow were now visible; and, with a certain degree of distinctness, I could see red, orange, yellow, green, and a fringe of blue. Fig. 4 shows the result.

The temperature was now carried to 1440°. I thought the red extremity was advancing more to the line A: the blue had undergone a well-marked increase. It reached considerably beyond the line G, as shown in fig. 5.

On bringing the platinum to 2130° all the colors were present, and exhibited considerable brilliancy. Their extent was somewhat shorter than that of the daylight spectrum, as is seen in fig. 6.

Having thus by repeated experiments ascertained the continued extension of the more refrangible end as the temperature rose, it became necessary to obtain observations for points below 1210°, the limit of visibility through the telescope. I therefore carried the prism nearer to the platinum, and looking with the unassisted eye directly through it at the refracted image, I found it could be distinctly seen at a temperature as low as 1095°. Under these circumstances the total length could not be compared by direct measurement with the other observations, and the result given in fig. 2 is from the best judgment I was able to form: the colors were red and greenish-gray.

The gray rays emitted by platinum just beginning to shine appear to be more intense than the red; at all events the wires in the field of the telescope are more distinctly seen upon them than upon the other color. I give them the designation of gray, for they appear to approach that tint more closely than any other; and yet it is to be remarked that they are occupying the position of the yellow and green regions.

Already we have encountered a fact of considerable importance. The idea, that as the temperature of a body rises it begins to emit rays of increasing refrangibility, has obviously to be taken with a certain restriction. Instead of first the red, then the orange, then the yellow, &c. rays, in succession, making their appearance, in which case the spectrum should regularly increase in length as the temperature rises, we here find, at the very first moment it is visible to the eye, it yields a spectrum reaching from the fixed line B to nearly F; that is to say, equal to about two-thirds the whole length of the interference spectrum, and almost one-half of the prismatic.

It is to be remarked, that while the more refrangible end undergoes a great expansion, the other extremity exhibits a corresponding though a less change. As very important theoretical conclusions depend on the proper interpretation of this fact, we must not forget that, to a certain extent, it may be an optical deception, arising from the increased brilliancy of the light. While the rays are yet feeble, the extreme terminations may be so faint that the eye cannot detect them; but as the intensity rises, they become better marked, and an apparent elongation of the spectrum is the consequence.

It is agreed by optical writers, that to the human eye the yellow is the brightest of the rays. In the prismatic spectrum the true relationship of the colors is not perceived, because the less refrangible are crowded together, and the more refrangible unduly spread out. But in the interference spectrum, where the colors are arranged side by side in the order of their wave-lengths, the centre is occupied by the most luminous portion of the yellow; and from this point the light declines away on one side in

the reds, and on the other in the blues, the terminations being equidistant from the centre of the yellow space.

Now if the rays coming from shining platinum were passed through a piece of glass, on which parallel lines had been drawn with a diamond point, so as to give an interference spectrum, even admitting the general results of the foregoing experiments to be true, viz. that as the temperature rises rays of a higher refrangibility are emitted, it is obvious that it by no means follows that the first ray visible should be the extreme red. Our power of seeing that depends on its having a certain intensity. Even when it has assumed that extreme brilliancy which it has in a solar beam it is barely visible. We ought therefore to expect that rays of a higher refrangibility should first be seen, because they act more energetically on our organ of vision; and as the temperature rises, the spectrum should undergo a partial elongation in the direction of its red extremity.

I may here remark, that the general result of these experiments coincides exactly with that of M. Melloni respecting heat and lower thermometric points. In this second memoir,* he shows that when the rays from copper at 390° and from incandescent platinum are compared by transmission through a rock-salt prism, as the temperature rises the refrangibility of the calorific emanations correspondingly increases. Those philosophers who regard light and heat as the same agent, will therefore see in this coincidence another argument in favor of their opinion.

In view of the foregoing facts I conclude, that, *as the temperature of an incandescent body rises, it emits rays of light of an increasing refrangibility;* and that the apparent departure from this law, discovered by an accurate prismatic analysis, is due to the special action of the eye in performing the function of vision.

As the luminous effects are undoubtedly owing to a vibratory movement executed by the molecules of the platinum, it seems from the foregoing considerations to follow, that the frequency of those vibrations increases with the temperature.

In this observation I am led by the principle, that "to a particular color there ever belongs a particular wave-length, and to a particular wave-length there ever belongs a particular color;" but in the analysis of the spectrum made by Sir D. Brewster by the aid of absorptive media, this principle is indirectly controverted; that eminent philosopher showing that red, yellow, blue, and consequently white light, exist in every part of the spectrum. This must necessarily take place when a prism which has a refracting face of considerable magnitude is used; for it is obvious

* Taylor's Scientific Memoirs, vol. i, p. 56.

that a ray falling near the edge, and one falling near the back, after dispersion, will paint their several spectra on the screen; the colors of the one not coinciding with, but overlapping the colors of the other. In such a spectrum there must undoubtedly be a general commixture of the rays; but may we not fairly inquire whether, if an elementary prism were used, the same facts would hold good; or, if the anterior face of the prism were covered by a screen, so as to expose a narrow fissure parallel to the axis of the instrument, would there be found in the spectrum it gave every color in every part, as in Sir David Brewster's original experiment? M. Melloni has shown how this very consideration complicates the phenomena of radiant heat; and it would seem a very plausible suggestion that the effect here pointed out must occur in an analogous manner for the phenomena of light.

I proceed now to the third branch of the inquiry,—to examine the relation between the temperatures of self-luminous bodies and the intensity of the light they emit, premising it with the following considerations.

The close analogy which is traced between the phenomena of light and radiant heat lends countenance to the supposition, that the law which regulates the escape of caloric from a body will also determine its rate of emission of light. Sir Isaac Newton supposed that whilst the temperature of a body rose in arithmetical progression, the amount of heat escaping from it increased in a geometrical progression. The fallacy of this was subsequently shown by Martin, Erxleben, and Delaroche; and finally Dulong and Petit gave the true law, "when a body cools *in vacuo*, surrounded by a medium whose temperature is constant, the velocity of cooling for excess of temperature in arithmetical progression increases as the terms of a geometrical progression, diminished by a constant quantity." The introduction of this constant depends on the operation of the theory of exchanges of heat; for a body, when cooling under the circumstances here given, is simultaneously receiving back a constant amount of heat from the medium of constant temperature.

Whilst Newton's law represents the rate of cooling of bodies, and therefore the quantities of heat they emit, when the range of temperature is limited, and the law of Dulong and Petit holds to a wider extent, there are in our inquiry certain circumstances to be taken into account not contemplated by those philosophers. Dulong and Petit throughout their memoir regard radiant heat as a homogeneous agent, and look upon the theory of exchanges, which is indeed their starting point and guide, as a very simple affair. But the progress of this department of knowledge since their times has shown, that precisely the same modifications as are found in the colors of light, occur also for heat; a fact conveniently designated by the phrase "ideal coloration of heat;"

and further, that the color of the heat emitted depends upon the temperature of the radiating source. It is one thing to investigate the phenomena of the exchanges of heat-rays of the same color, and another when the colors are different. A perfect theory of the exchanges of heat must include the principle of ideal coloration, and, of course, so too must a law of cooling applicable to any temperature.

There is another fact to some extent considered by Dulong and Petit, but not of such weight in their investigations, where the range of temperature was small, as in ours, where it rises as high as nearly 3000° F.; I mean the difference of specific heat of the same body at different temperatures. At the high temperatures considered in this memoir, there cannot be a doubt that the capacity of platinum for heat is far greater than that at a low point. This therefore must control its rate of calorific emission, and probably that for light also.

From these and similar considerations, we should be prepared to discover that as the temperature of an incandescent solid rises, the intensity of the light emitted increases very rapidly.

I pass now to the experimental proofs which substantiate the foregoing reasoning.

The apparatus employed as the source of the light and measure of the temperature was the same as in the preceding experiments,—a strip of platinum, brought to a known temperature by the passage of a voltaic current of the proper force, and connected with an index which measured its expansion.

The principle upon which I have determined the intensity of the light is that first described by Bouguer, and recently introduced by M. Masson. After many experiments I have been led to conclude that this is the most accurate method known.

Any one who will endeavor to determine the intensities of lights by Rumford's method of contrasting shadows, or by that of equally illuminated surfaces, will find, when every precaution has been used, that the results of repeated experiments do not accord. There is moreover the great defect, that where the lights differ in color it is impossible to obtain reliable measures, except by resorting to such contrivances as that described by me.*

Bouguer's principle is far more exact; and where the lights differ in color, that difference actually tends to make the result more perfect. As it is not generally known, I will indicate the nature of it briefly.

Let there be placed at a certain distance from a screen of white paper, a candle so arranged as to throw the shadow of a ruler. or other opake body, on the screen. If a second candle be placed also in front of the paper and nearer than the former, there is a cer-

* Phil. Mag., August, 1844.

tain distance at which its light completely obliterates all traces of the shadow. This distance is readily found; for the disappearance of the shadow can be determined with considerable exactness. When the lights are equal, Bouguer found that the relative distances were as 1 : 8; he inferred therefore, correctly, that in the case of his eye, the effect of a given light was imperceptible when it was in presence of another sixty-four times as intense. The precise number differs according to the sensibility of different eyes, but for the same organ it is constant.

Upon a paper screen I threw the shadow of a piece of copper, which intercepted the rays of the incandescent platinum: then taking an Argand lamp, surrounded by a cylindrical metal shade through an aperture in which the light passed, and the flame of which I had found by previous trial would continue for an hour almost of the same intensity, I approached it to the paper until the shadow cast by the copper disappeared. The distance at which this took place was then measured, and the temperature of the platinum determined.

The temperature of the platinum was now raised; the shadow became more intense, and it was necessary to bring the Argand lamp nearer before it was effaced. When this took place the distance of the lamp was again measured, and the temperature of the platinum again determined.

In this manner I obtained several series of results, one of which is given in the following table. They exhibited a more perfect accordance among each other than I had anticipated. The intensity of the light of the platinum is of course inversely proportional to the square of the distance of the Argand lamp at the moment of the obliteration of the shadow.

*Table of the Intensity of Light emitted by Platinum at different Temperatures.*

| Temperature of the platinum. | Distance of Argand lamp. | | Mean. | Intensity of light. |
|---|---|---|---|---|
| | Experiment 1. | Experiment 2. | | |
| 980° | .... | .... | .... | 0·00 |
| 1900 | 54·00 | 54·00 | 54·00 | 0·34 |
| 2015 | 39·00 | 41·00 | 40·00 | 0·62 |
| 2130 | 24·00 | 24·00 | 24·00 | 1·73 |
| 2245 | 18·00 | 19·00 | 18·50 | 2·92 |
| 2360 | 14·50 | 15·50 | 15·00 | 4·40 |
| 2475 | 11·50 | 12·00 | 11·75 | 7·24 |
| 2590 | 9·00 | 9·00 | 9·09 | 12·34 |

In this table the first column gives the temperatures under examination in Fahrenheit degrees; the second and third the distances of the Argand lamp from the screen, in English inches, in two different sets of experiments: the fourth the mean of the two: and the fifth the corresponding intensity of the light.

From this it is at once perceived, that the increase in the intensity of the light, though slow at first, becomes very rapid as

the temperature rises. *At* 2590° *the brilliancy is more than thirty-six times as great as it is at* 1900°.

Thus, therefore, the theoretical anticipation which we founded on the analogy of light and heat is completely verified; and we discover that as the temperature of a self-luminous solid rises, it emits light in a greater proportion than would correspond to the mere difference of temperature. To place that analogy in a still more striking point of view, I will here introduce some experiments I have made in relation to radiant heat. No chemist, so far as I am aware, has hitherto published results for high temperatures, or endeavored to establish, through an extensive scale, the principle of Delaroche, that "the quantity of heat which a hot body gives off in a given time by way of radiation to a cold body, situated at a distance, increases, other things being equal, in a progression more rapid than the excess of the temperature of the first above that of the second."

As my object on the present occasion is chiefly to illustrate the remarkable analogy between light and heat, the experiments now to be related were arranged so as to resemble the foregoing; that is to say, as in determining the intensities of light emitted by a shining body at different temperatures, I had received the rays upon a screen placed at an invariable distance, and then determined their value by photometric methods; so, in this case, I received the rays of heat upon a screen placed at an invariable distance, and determined their intensity by thermometric methods. In this instance the screen employed was in fact the blackened surface of the thermo-electric pile. It was placed at a distance of about one inch from the slip of incandescent platinum, a distance sufficient to keep it from any disturbance from the stream of hot air arising from the metal; care also was taken that the multiplier itself was placed so far from the rest of the apparatus, that its astatic needles could not be affected by the voltaic current igniting the platinum, or the electro-magnetic action of the wires used to modify the degrees of heat.

The experiments were conducted as follows:—The needles of the thermo-multiplier standing at the zero of their scale, the voltaic current was passed through the platinum, which immediately rose to the corresponding temperature, and radiated its heat to the face of the pile. The instant the current passed, the needles of the multiplier moved, and kept steadily advancing upon the scale. At the close of one minute, the deviation of the needle and the temperature of the platinum were simultaneously noted, and then the voltaic current was stopped.

Sufficient time was now given for the needle of the multiplier to come back to zero. This time varied in the different cases, according to the intensity of the heat to which the pile had been exposed: in no instance, however, did it exceed six minutes, and

in most cases was much less. A little consideration will show that the usual artifice employed to drive the needles back to zero by warming the opposite face of the pile, was not admissible in these experiments.

The needles having regained their zero, the platinum was brought again to a given temperature, and the experiment conducted as before. The following table exhibits a series of these results.

*Table of the Intensity of Radiant Heat emitted by Platinum at different Temperatures.*

| Temperature of the platinum. | Intensity of heat emitted. | | Mean. |
|---|---|---|---|
| | Experiment 1. | Experiment 2. | |
| 980° | ·75 | 1·00 | ·87 |
| 1095 | 1·00 | 1·20 | 1·10 |
| 1210 | 1·40 | 1·60 | 1·50 |
| 1325 | 1·60 | 2·00 | 1·80 |
| 1440 | 2·20 | 2·20 | 2·20 |
| 1555 | 2·75 | 2·85 | 2·80 |
| 1670 | 3·65 | 3·75 | 3·70 |
| 1785 | 5·00 | 5·00 | 5·00 |
| 1900 | 6·70 | 6·90 | 6·80 |
| 2015 | 8·60 | 8·60 | 8·60 |
| 2130 | 10·00 | 10·00 | 10·00 |
| 2245 | 12·50 | 12·50 | 12·50 |
| 2360 | 15·50 | 15·50 | 15·50 |

In this table the first column gives the temperatures of the platinum in Fahrenheit degrees; the second and third two sets of experiments, expressing the arc passed over by the needle at the close of a radiation lasting for one minute, each number being the mean of several successive trials; and the fourth the mean of the two. It therefore gives the radiant effect of the incandescent platinum upon the thermo-multiplier for the different temperatures.

Of course it is understood that I here take the angular deviations of the needle as expressing the force of the thermo-electric current, or in other words, as being proportional to the temperatures. This hypothesis, it is known, is admissible.

It therefore appears that the quantity of heat radiated by incandescent platinum at 980° being taken as unity, it will have increased at 1440° to 2·5; at 1900° to 7·8; and at 2360° to 17·8, nearly: the rate of increase is therefore very rapid. Further, it may be remarked, as illustrative of the same fact, that the increased quantity of heat radiated by a mass of platinum in passing from 1000° to 1300°, is nearly equal to the amount it gives out in passing from common temperatures up to 1000°.

I cannot here express myself with too much emphasis on the remarkable analogy between light and heat which these experiments reveal. The march of the phenomena in all their leading points is the same in both cases. The rapid increase of effect as the temperature rises is common to both.

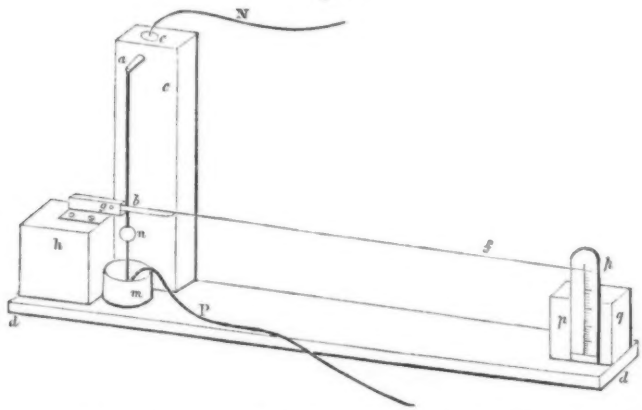
It is not to be forgotten, however, that in the case of light we necessarily measure its effects by an apparatus which possesses special peculiarities. The eye is insensible to rays which are not comprehended within certain limits of refrangibility. In these experiments, it is requisite to raise the temperature of the platinum almost to 1000° before we can discover the first traces of light. Measures obtained under such circumstances are dependent on the physiological action of the visual organ itself, and hence their analogy with those obtained by the thermometer becomes more striking, because we should scarcely have anticipated that it could be so complete.

*Description of the apparatus employed in the foregoing experiments.*

The source of light is in all instances a slip of platinum foil 1·35 inch long, and $\frac{1}{25}$th of an inch broad, ignited by the passage of a voltaic current, and placed in such a position that its dilatation could be measured by the movements of an index over a graduated scale.

In fig. 7, *a b* represents the slip of platinum, the upper end of which is soldered to a stout and short copper pin *a*, firmly sunk in a block of wood *c*, which is immovably fastened on the basis *d d* of the instrument. A cavity *e*, half an inch in diameter, is sunk in the block *c*, and into this cavity the pin *a* projects; so that when the cavity is filled with mercury, a voltaic current may be passed through the pin and down the platinum.

Fig. 7.




The other extremity of the platinum *b* is fastened to a delicate lever *b f*, which plays on an axis at *g*, the axis working in brass holes supported on a block *h*. Immediately beneath the pla-

tinum strip, and in metallic communication with it, a straight copper wire dips down into the mercury cup *m*; on this wire there is a metal ball *n*, weighing about 100 grains. The further end of the index plays over a graduated ivory scale *p p*, which is supported on a block *q*, and can be moved a little up and down, so as to bring its zero to coincide with the index at common temperatures.

The action of the instrument is readily understood. In the mercury cup *e* dip one of the wires N of a Grove's battery of three or four pairs, the other wire P being dipped into the cup *m*. The current passes through the platinum, which immediately expands, the weight *n* lightly stretching it. The index *f* moves promptly over the scale, indicating the amount of expansion, and therefore the degree of heat. Remove the wire N out of its mercury cup *e*, the platinum instantly becomes cold, and pulls the lever to the zero point.

When the platinum is thin, so as to be quite flexible at the point *b*, where it is fastened to the index, the movements take place with such promptitude and precision as to leave nothing to be desired. When the heat has been very high and long continued, the limit of elasticity of the platinum is somewhat overpassed, and it suffers a slight permanent extension. But as the ivory scale *p p* can slide up and down a little, the index is readily re-adjusted to the zero point.

The temperature of the platinum depends entirely on the force of the current passed through it. By intervening coils of brass wire of lengths adjusted beforehand, so as to resist the current to a given extent, any desired temperature may be reached. I found it convenient to intervene in the course of the current one of Prof. Wheatstone's rheostats, so as to be able to bring the index with precision to any degree, notwithstanding slight changes in the force of the voltaic battery.

The following are the dimensions and measures of the instrument I have used:—Length of the platinum strip, 1·35 inch; length of the part actually ignited, 1·14 inch; width of ditto, $\frac{1}{20}$th of an inch; length of the index from its centre of motion to the scale, 7·19 inches; distance of the centre of motion of index from the insertion of the platinum at the point *b*, ·22 inch; multiplying effect of the index, 32·68 times; length of each division on the ivory scale, ·021 inch. From this it would appear, by a simple calculation, using the coefficient of dilatation of platinum given by Dulong and Petit, that each of the divisions here used is equal to 114·5 Fahrenheit degrees. For the sake of perspicuity I have generally taken them at 115°.

The Grove's battery I have employed has platinum plates three inches long and three-quarters wide; the zinc cylinders are two inches and a half in diameter, three high, and one-third

thick. As used in these experiments, it could maintain a current nearly uniform for an hour. I commonly employ four pairs.

Among writers on optics, it has been a desideratum to obtain an artificial light of standard brilliancy. The preceding experiments furnish an easy means of supplying that want, and give us what might be termed a "unit-lamp." A surface of platinum of standard dimensions, raised to a standard temperature by a voltaic current, will always emit a constant light. A strip of that metal, one inch long and $\frac{1}{20}$th of an inch wide, connected with a lever by which its expansion might be measured, would yield at 2000° a light suitable for most purposes. Moreover, it would be very easy to form it an available photometer, by screening portions of the shining surface. An ingenious artist would have very little difficulty, by taking advantage of the movements of the lever, in making a self-acting apparatus, in which the platinum should be maintained at a uniform temperature, notwithstanding any change taking place in the voltaic current.

University, New York, Feb. 27, 1847.

---

ART. XXXVI.—*On the Changes which the Albuminous Substances undergo in the Stomach, during the process of Digestion;* by Prof. MULDER, of Utrecht. (Translated from the Dutch, by Dr. AUG. VÖLCKER.)

I LAST year demonstrated,* that the fibrin of blood undergoes no change in composition by solution in muriatic acid and precipitation by carbonate of ammonia.

The results of my analysis, employing in the present instance my last experiments on the amount of sulphur in these substances, were as follows:—

| | Undissolved fibrin. | Dissolved and thrown down with carbonate of ammonia. |
|---|---|---|
| C, | 52·7 | 52·7 |
| H, | 6·9 | 6·9 |
| N, | 15·4 | 15·8 |
| O, | 23·5 | 23·5 |
| S, | 1·2 | 1·1 |
| Ph, | 0·3 | |

The phosphorus has not been determined in the dissolved portion; but as vitellin loses phosphamid under the influence of acetic acid and ammonia,† it is probable that fibrin will have been deprived of the phosphamid under the influence of muriatic acid and carbonate of ammonia.

---

* Scheik. Onderz., Deel iii, p. 470.

† Von Baumhauer in Scheik. Onderz., Deel iii, p. 284.

The same experiments were repeated on casein and albumin, and the following results obtained.

A small quantity of muriatic acid was added to milk; a precipitate fell, which was washed for a long time with water. At last the mass began to be gelatinous; in this state it was mixed with water and set aside at a temperature of about 40° C. After some hours the whole was dissolved, and the butter rose to the top. The watery solution was decanted, thrown down by carbonate of ammonia, and the precipitate washed with water, alcohol and ether, and dried at a temperature of 130° C.

0·5568 grms. produced 0·0033 ash.

I. 1·586 " gave after being burned with caustic soda and nitre, 0·07, Ba O, $SO^3$.

II. 1·914 grms. gave 0·101, Ba O, $SO^3$.

I. 0·6512 " without ash, gave 83 cub. cent. of moist N at 16°·5 and 766 m. m.

II. 0·6542 " without ash, " 85 cub. cent. of moist N at 16°·5 and 766 m. m.

I. 0·5652 " free of ash, " 1·1065 $CO^2$ and 0·3569 $H^2O$.

II. 0·6113 " " " " 1·1885 " " 0·3816 "

| | Undissolved casein.* | Dissolved and thrown down. | |
|---|---|---|---|
| C, | 53·8 | 53·44 | 53·08 |
| H, | 7·1 | 7·01 | 6·93 |
| N, | 15·6 | 15·01 | 15·30 |
| O, | 22·6 | 23·93 | 23·96 |
| S, | 0·9 | 0·61 | 0·73 |

Casein as I have shown as well as Schlossberger,† is a complex body; it consists of different protein compounds, of which the body that I have now studied constitutes the chief element. It is characterized by a somewhat smaller amount of sulphur, and is distinguished besides from the mixture hitherto called casein, by the circumstance that it contains more oxygen. It shows the reaction of sulphamid-protein.

| | | Without $SN^2H^4$. | |
|---|---|---|---|
| C, | 53·5 | 53·4 | 54·1 |
| H, | 7·0 | 6·9 | 7·0 |
| N, | 15·0 | 14·5 | 14·7 |
| O, | 23·9 | 23·9 | 24·2 |
| S, | 0·6 | .... | .... |
| | 100·0 | 98·7 | 100·0 |

*Albumin of eggs*, coagulated by heat, was mixed with diluted muriatic acid, and after the addition of a small piece of rennet, set aside at a temperature of 40° C. After some days the albumin was completely dissolved. To the filtered liquid carbonate

* Scheik. Onderz., Deel iv, p. 278.

† Ibid, Deel iii, p. 453, and Annalen der Chemie und Pharmac., April, 1846, p. 92.

of ammonia was added, and the precipitate washed with water, alcohol and ether, and dried at 130° C.

0·745 gave 0·004 ash.

I. 0·645, free of ash, 87 of moist N at 17°·5 C. and 766 m. m.
II. 0·640, " " 85 " " " " " " " "
I. 0·573, " " 1·107 $CO^2$ and 0·358 $H^2O$.
II. 0·513, " " 0·998 " " 0·319 "

I. 1·103 gave 0·1465 of sulphate of barytes, by means of caustic soda and nitre.

II. 0·938 gave 0·118 of sulphate of barytes.

| | Undissolved albumin.* | Dissolved and precipitated. I. | Dissolved and precipitated. II. | Mean. |
|---|---|---|---|---|
| C, | 53·5 | 52·74 | 53·11 | 53·0 |
| H, | 7·0 | 6·93 | 6·93 | 6·9 |
| N, | 15·5 | 15·97 | 15·60 | 15·8 |
| O, | 22·0 | 22·53 | 22·63 | 22·5 |
| S, | 1·6 | 1·83 | 1·73 | 1·8 |
| Ph, | 0·4 | . . . | . . | . . |

The phosphorus, probably not contained in the precipitated albumin, was not determined. The quantity of the sulphur exceeds that in albumin by 0·2; however, I do not doubt that this increase must only be ascribed to an error of experiment. It showed at any rate the reaction of sulphamid.

| | | Without $SN^2H^4$. | |
|---|---|---|---|
| C, | 53·0 | 53·0 | 54·9 |
| H, | 6·9 | 6·8 | 7·0 |
| N, | 15·8 | 14·2 | 14·7 |
| O, | 22·5 | 22·5 | 23·4 |
| S, | 1·8 | . . . | . . . |
| | 100·0 | 96·5 | 100·0 |

Thus albumin has not been changed in composition, as regards the C, N, H, O and $SN^2H_4$, and it appears that no new combination of albumin is produced during the digestion in the stomach. Is this the case also with casein? No other conclusions can be drawn from the above analysis than that, either casein contains already a substance richer in oxygen, or that the production of such a combination is caused during the solution in the stomach.

Let us now compare the organic group which remains, after deducting the elements of sulphamid from fibrin, hair and this dissolved casein:—

| | Fibrin. | Hair. | Dissolved casein. |
|---|---|---|---|
| C, | 54·4 | 53·6 | 54·1 |
| H, | 7·0 | 7·1 | 7·0 |
| N, | 14·4 | 14·6 | 14·7 |
| O, | 24·2 | 24·7 | 24·2 |

* Scheik. Onderz., Deel iv, p. 223.

and let us place next to it the group, occurring originally in casein and albumin:

| | Casein. | Albumin from eggs. | Albumin from blood. |
|---|---|---|---|
| C, | 54·8 | 55·6 | 55·0 |
| H, | 7·1 | 7·1 | 7·2 |
| N, | 15·1 | 14·4 | 14·5 |
| O, | 23·0 | 22·9 | 23·3 |

it will now easily be seen, that there exists a considerable difference. In the first three groups is contained evidently less C and more O.

They are expressed by

| | Atoms. | Calculated. |
|---|---|---|
| C, | 36 | 53·6 |
| H, | 54 | 6·7 |
| N, | 8 | 13·9 |
| O, | 13 | 25·8 |

The first change of the albumin in the stomach is therefore only solution; that of casein may also be oxydation. I say it may be, for it is possible that this group already preëxists in casein. This can only be determined with certainty when the other constituents of casein shall have been farther examined.

At all events, in casein, after its solution in the stomach, the same organic group exists as in fibrin, and there is so far an intimate relation between fibrin and casein. Casein must easily produce fibrin, while albumin remains still albumin in the stomach and probably undergoes no other change, except in the proportion of sulphamid it contains.

The question now is, how far the use of milk will be advisable in inflammatory diseases. I address this question to medical experience, but I am far from establishing any opinion, upon the numerical results of experiments. Medical experience has its own rights, as well as chemistry. The one must not dictate to the other, but to propose such questions is both the right and the duty of chemistry.

---

## SCIENTIFIC INTELLIGENCE.

### I. Chemistry and Physics.

1. *On the Atomic Volume of some Isomorphous Oxyds of the regular system;* by Chas. Gerhardt.—It is known that analogous isomorphous compounds possess the same atomic volume. This volume however, is not rigorously the same, on account of the differences which naturally exist between the angles of isomorphous substances, or the variations of temperature and density under which they have been taken, which last alone modifies the angles of the crystals by an unequal dilatation of their axes. As this influence of heat upon the angles is in effect noth-

ing for those crystals which possess a simple refraction, and as the angles of these last are not subject to the slight variations which affect the results in other isomorphous groups, it appeared to me of interest to verify the principle of M. H. Kopp,* upon some oxyds crystallizing in the regular system.

Mineralogy presents us many compounds crystallizing in the regular system to which chemistry applies the most diverse formulas. I here cite them with the notation of Berzelius.

| | | Specific weight. |
|---|---|---|
| Magnetic iron, | $(FeO, Fe_2O_3)$ | 5·094 |
| Octahedral oligist iron (martite), | $(Fe_2O_3)$ | 4·76 to 4·65 |
| Spinelle, | $(MgO, Al_2O_3)$ | 3·48 to 3·62 |
| Gahnite, | $(ZnO, Al_2O_3)$ | 4·23 |
| Ceylanite, of the Ural, (Abich) | $(FeO, Al_2O_3)+2(MgO, Al_2O_3)$ | 3·6 to 3·8 |
| " of Vesuvius, (Abich) | $(FeO, Al_2O_3)+9(MgO, Al_2O_3)$ | |
| Chlorospinelle of Slatoust, (G. Rose,) | $(MgO, Fe_2O_3)+11(MgO, Al_2O_3)$ | 3·59 |
| " " " (G. Rose) | $(MgO, Fe_2O_3)+6(MgO, Al_2O_3$ | |
| Chromic iron (crystallized), Baltimore, (Abich,) | $5(MgO, Cr_2O_3)+(FeO, Cr_2O_3)$ $+3(FeO, Al_2O_3)$ | 4·3 to 4·5 |
| do. do. (compact), Baltimore, (Abich,) | $6(MgO, Cr_2O_3)+(FeO, Cr_2O_3)$ $+2(MgO, Al_2O_3)+(FeO, Al_2O_3)$ | |
| do. do. St. Domingo, (Berthier,) | $(Cr_2O_3, Fe_2O_3)+(Al_2O_3)$ | |
| Titanic iron, Mount Ilmen, (Mosander,) | $8(FeO, TiO_2)+Fe_2O_3$ | 4·715 to 4·78 |
| " " Egersund, (H. Rose,) | $6FeO, TiO_2)+Fe_2O_3$ | |
| " " Egersund, (Mosander,) | $3FeO, TiO_2)+Fe_2O_3$ | |
| " " Arendal, (Mosander,) | $(FeO, TiO_2)+Fe_2O_3$ | |
| " " Uddevalla, (Plantamour,) | $2(FeO, TiO_2)+5Fe_2O_3$ | |
| Franklinite, (Abich,) | $(FeO, Mn_2O_3)+(ZnO, Fe_2O_3)$ | 5·19 |
| Periclase, (Damour,) | $(18MgO, Fe_2O_3)$ | 3·75 |
| Perowskite, (H. Rose,) | $(CaO, TiO_2)$ | 4·017 |
| Braunite,† | $(Mn_2O_3)$ | 4·75 to 4·818 |

It is difficult to unite formulas so complicated and so diverse as those which represent these oxyds, and it often happens that the same mineral species will be expressed by very different formulas although the crystalline form remains exactly the same. If we search for a relation between the specific gravities of these minerals and their atomic weights

* Annal. de Chim. et de Phys., 2d series, t. lxxv, p. 406.

† The octahedrons of braunite do not belong to the regular system; the angle of two adjacent faces upon the pyramid is 109°·53′; (over the basal edge 108°·39′.) for the crystals of Agersburg: and 109°·46′ (over the basal edge 108°·33′) for those of St. Marcel, while it is 109°·28′ 16″ in the regular octahedron. But this difference is not so great as that which exists between the angles of substances regarded as isomorphous, as for example, those of the different carbonates, of the rhombohedral system.

We may perhaps add to the preceding list the *Hausmannite*, or manganoso-manganic oxyd, which crystallizes in octahedrons with a square base. The difference between the angles is however, much greater, (105°·25′ and 117°·54′.) We may here inquire to what limit the angles may differ in substances considered as isomorphous. See on this subject the views of Mr. Laurent, (Compt. Rend. der Trav. de Chimie, 1845, p. 97.)

according to the preceding formulas, we fail to find it, and often are surprised to see that the specific weight of a mineral presents but slight oscillations which scarcely accord with the widely varying composition attributed to its different varieties. For example, it is not easy to understand why titaniferous iron has always a specific weight, varying only from 4·745 to 4·78, while it is composed sometimes of equal equivalents of ferric oxyd and ferrous titanate, and sometimes of one equivalent of ferric oxyd and six equivalents of ferrous titanate.

These anomalies disappear entirely if we write all these oxyds after one formula, $OM_2$ similar to that of water $OH_2$, and in which M can be replaced by different metals in indefinite proportions, provided that the sum of the equivalents of these metals are equal to 2.*

See the oxyds thus represented with their atomic volume, which equals the product of the atomic weight divided by the density.

| | | Mean. |
|---|---|---|
| Type oxyd, | $OM_2$ | 11·0 |
| Oligist iron, | $OFe^{\beta}_{2}$ | 11·4 |
| Braunite,† | $OMn^{\beta}_{2}$ | 11·2 |
| Magnetic iron, | $O(Fe^{\beta}_{\frac{1}{2}}Fe^{\frac{1}{2}})_2$ | 11·4 |
| Gahnite, | $O(Al^{\beta}_{\frac{1}{2}}Zn^{\frac{1}{2}})_2$ | 10·9 |
| Spinelle, | $O(Al^{\beta}_{\frac{1}{2}}Mn^{\frac{1}{2}})_2$ | 10·6 |
| Ceylanite, | $O(Al^{\beta x}Fe^{y}Mg^{z})_2$ | 10·6 |
| Chlorospinelle, | $O(Al^{\beta x}Fe^{\beta y}Mg^{z})_2$ | 10·6 |
| Chromic iron, | $O(Al^{\beta u}Fe^{\beta v}Cr^{\beta x}Mg^{y}Fe^{z})_2$ | 11·2 |
| Titaniferous iron, | $O(Ti^{\alpha x}Fe^{\beta y}Fe^{z})_2$ | 10·9 |
| Franklinite, | $O(Fe^{\beta v}Mn^{\beta x}Zn^{y}Fe^{z})_2$ | 11·1 |
| Perowskite, | $O(Ti^{\alpha}_{\frac{1}{2}}Ca^{\frac{1}{2}})_2$ | 11·2 |
| Periclase, | $O(Fe^{\beta y}Mg^{z})_2$ | 10·9 |

I am obliged to indicate by letters the most of those fractional numbers, of which the sum is equal to two equivalents. It is easy to replace these letters by their numerical values, which are derived from the formulas we have previously given. In the same manner I suppress the details of the calculations relative to the atomic volume.

This volume, it is to be remarked, is essentially the same for all the oxyds mentioned; there are but slight differences apparent, which are due to the fact that in calculating these formulas, we have not always taken into account those oxyds which are contained in small quantities in the minerals. It is very rare that a mineral is chemically pure, and as the presence of a very small quantity of any foreign substance always modifies the specific weight, it is evident that we cannot obtain a number rigorously exact in dividing the specific weight by the atomic weight of the substance supposed to be chemically pure.

---

* It is necessary to recollect that $Fe^{\beta}_{\frac{2}{3}}$, $Al^{\beta}_{\frac{2}{3}}$, $Cr^{\beta}_{\frac{2}{3}}$, $Mn^{\beta}_{\frac{2}{3}}$=Feβ (ferricum), Alβ (aluminicum), Crβ (chromicum), Mnβ (manganicum), are the equivalent of H, Fe (ferrosum), Mn (Manganosum), Mg (magnesium), etc., because an oxyd $M_4O_2$ reacts with six equivalents of hydrogen to form $3H_2O$, $M_4$ resting in the place of $H_6$. If we represent the oxyd of titanium by $Ti_2O_2$($TiO_2$, Berzelius), $Ti_2$ becomes equal to $H_4$: then $Ti^{\frac{1}{2}}$=$Ti_{\alpha}$ equals H.

[It will be remembered that M. Gerhardt divides the ordinarily received equivalents of hydrogen and the metals. The protoxyds MO then become $M_2O$, and the sesquioxyds $M_2O_3$, $M_4O_3$. See this Journal, p. 171, this volume.]

† The Hausmannite D=4·22 gives an atomic volume of 12·2.

It is not, however, necessary to suppose that all the oxyds crystallizing in the regular system, have the same atomic volume. We know by the study of polymeric bodies, that the same elements may be differently condensed: thus a volume of elaldehyde in vapor contains three times as much carbon, hydrogen and oxygen, as the same volume of aldehyde in the same state. A similar relation may exist for solids and liquids. A volume of an oxyd may contain $OM_2$, $O_2M_4$ or $O_3M_6$, or in general $OnM_2n$, but if the atomic volume of an oxyd $OM_2$ is V, the volume of its polymere will be $V^n$. There may then be oxyds crystallizing in regular octahedrons, having an atomic volume different from that of the preceding oxyds.

The protoxyd of copper $Cu_4O$, and the arsenious anhydride $As_2O_3$, are illustrations in point; if we calculate the atomic volume of these oxyds, reducing their formulas to the expression $OM_2$, we obtain 23·6 for one and 18·0 for the other; these numbers are approximate multiples of the atomic volume of the preceding minerals by 2 and $1\frac{1}{2}$. It is as if the molecule of protoxyd of copper* was $O_2Cu\alpha_4$, and that of arsenious anhydride $O1\frac{1}{2}As\alpha_3$ in relation to the molecule $OM_2$ of those minerals. Beside this we do not indicate whether the type in which we have placed these last, be $OM_2$ more than $O_2M_4$, $(OM_2, OM_2)$ or $O_3M_6=(OM_2, OM_2, OM_2)$; we shall be able to establish our considerations upon all other formulas, provided that it is *the same* for all the oxyds. It is nothing in effect but a question of ratios.

2. *On the Acid contained in the North American Columbite;* by Henry Rose, (L., E. and D. Phil. Mag., xxx, 360, from Poggend. Annal.)—The columbite of North America has the same crystalline form as that from Bodenmais and Bavaria, but is distinguished from it in general by a lower specific gravity; however, we find the same difference in the specific gravity of the American mineral as occurs in the different crystals of the Bodenmais columbite. The lightest crystals from the last locality have the same specific gravity (5·704) as the heaviest crystals from North America (5.708).

I have already communicated two analyses of North American columbites, one of which however it was doubtful whether it came from America. The following analysis of American columbite was made by M. Grewink in my laboratory; it yielded,—

| | |
|---|---|
| Acid, . . . . . | 80·06 |
| Protoxyd of iron, . . . . | 12·59 |
| Protoxyd of manganese, . . . . | 5·97 |
| Oxyd of tin, . . . . . | 0·96 |
| Oxyd of copper and lead, . . . . | 0·44 |
| | 100·02 |

The specific gravity in fragments was 5·323; in powder, 5·3202.

This columbite comes nearest in composition and also in specific gravity to that examined by M. Schlieper.

I have on a former occasion shown that the different specific gravity of the crystals of the Bavarian columbite was owing to the different proportions of niobic and pelopic acids which are found in the different

* $Cu_\alpha = Cu_2$, cuprosum; $As_\alpha = As_{\frac{2}{3}}$ arseniosum.

crystals. The specific gravity of these two acids is widely different, but unequally so, according to the temperatures to which they have been exposed previous to weighing.

Owing to want of material, I found it impossible to make a thorough examination of the two acids which are contained in the North American columbite: I very soon ascertained, after the discovery of niobic acid, that this was the principal acid constituent in the American columbite, but I could not determine whether it was mixed with pelopic or with tantalic acid; I therefore addressed myself to Mr. B. Silliman, of New Haven, who with the greatest readiness procured me a very considerable quantity (half a pound) of this now very rare mineral.

A large quantity of this columbite was used for the preparation of the acid. When treated in the same manner as that from the Bavarian columbite, it proved to consist principally of niobic acid combined with pelopic acid; but the amount of the latter was far smaller than in the Bodenmais mineral, so that I do not think it would have been possible for me to have examined the properties of pelopic acid so completely as was necessary in order to recognize it as an essentially distinct acid from tantalic acid, if I had had only the American mineral at my disposal. But both the acids were so perfectly identical in all their properties with the two acids prepared from the Bodenmais mineral, that I did not find the least difference, even as regards the specific gravity.

As the specific gravity of pelopic acid is considerably higher than that of niobic acid, when the two are heated in the same manner, the higher specific gravity of the Bavarian columbite is thus satisfactorily explained.

I have moreover found small quantities of tungstic acid in the acids from the American columbite, as well as in those from the Bodenmais mineral.

3. *Diamond converted to Coke*, (Proc. Brit Assoc., 1847, Athen., No. 1028.)—Dr. Faraday exhibited some diamonds, which he had received from M. Dumas, which had, by the action of intense heat, been converted into coke. In one case, the heat of the flame of oxyd of carbon and oxygen had been used—in another the oxyhydrogen flame—and in the third the galvanic arc of flame from a Bunsen battery of 100 pairs. In the last case, the diamond was perfectly converted into a piece of coke,—and in the others the fusion and carbonaceous formation were evident. Specimens, in which the character of graphite was taken by the diamond, were also shown. The electrical characters of these diamonds were stated also to have been changed,—the diamond being an insulator, while coke is a conductor.

4. *On Different Properties of the Various Rays of the Solar Radiation on the Daguerreotype Plate prepared with Iodine, Chlorine and Bromine, in producing and preventing the Fixation of Mercurial Vapor;* by A. Claudet, (Proc. Brit. Assoc., 1847, Athen., No. 1027.)—M. Claudet has made a series of observations upon light transmitted through certain coloring media, through the vapors of the atmosphere, and through red, orange and yellow glasses. Having directed a camera obscura upon the sun when its disc appeared quite red, he obtained after ten seconds a black image of the sun. The red sun had produced no photogenic effect, although the surrounding spaces had been

sufficiently affected by the photogenic rays proceeding from the zenith to attract the white vapors of mercury. This proved that the red rays had no photogenic power. He then operated in a different manner; not content with the slow motion of the sun, he moved the camera obscura from right to left and *vice versâ*. In this manner the sun had passed rapidly over five or six zones of the plate. Its passage was marked by long black bands, whilst the intervening spaces were white; showing again that it was sufficient in order to destroy the action of the photogenic rays to let red rays pass rapidly over the spaces previously affected by them. He operated afterwards with colored glasses; after having obtained upon a Daguerreotype plate the impression of a black lace by white light, he covered one half of the plate and exposed the other half to the radiation of a red glass. The mercury developed an image of the lace on the part which had been acted on only by the white light, and the other part which had afterwards received the action of the red rays remained black. The red glass had destroyed the photogenic effect, as had taken place with the red light of the sun. He made the same experiments with orange and yellow glasses, and obtained the same results but in different periods of time. The photogenic action of the red rays is 5,000 times longer than the white light, that of the orange is 500 times longer and that of the yellow 100 times. The destructive action of the red rays is 100 times longer than that of white light; the orange 50 times, and yellow only 10 times. When a plate has been exposed to the destructive action of any particular ray, it cannot be affected photogenically by the radiation which has destroyed the first effect; it is only sensitive to the other radiations.

Mr. R. Hunt remarked that his own observations had led him to the conclusion, that instead of having to deal with three differently colored rays, we had to deal with three distinct principles,—these three colors being a property of only one of them. Light, heat, and actinism he regarded as antagonistic forces; and it was only because they were found in different proportions in the three classes of colored rays that the results of M. Claudet could be in any way associated with the colors of light.—Mr. Maskelyne objected to some of these conclusions.

5. *Report on the Influence of Light on the Growth of Plants;* by R. Hunt, (Proc. Brit. Assoc., 1847, Athen., No. 1027.)—The author confirms the conclusions that seeds will not germinate under the influence of light separated from the chemical principle with which it is associated in the sunbeam; that germination being effected and the first leaves formed, light—the luminous rays—become essential to the plant to enable it to secrete the carbon obtained from the carbonic acid of the atmosphere; and that the increased action of the heat rays is essential to insure the production of the reproductive elements of vegetable life. It is found that the chemical principle of the solar rays is more active, relatively to heat and light, during the spring than at any other period of the year; that as summer advances this power diminishes and luminous force increases, whilst with the autumn both light and actinism are subdued, but the calorific radiations increased. Thus we find the conditions of the light of the seasons varying to suit the necessities of vegetable life. The production of chlorophyl, or the coloring matter of the leaves, was shown to be due to the joint

action of light and actinism—the first being necessary to effect the secretion of the carbon and the latter for the oxydation of this deposited carbon.

6. *On the Application of Photography to copying Microscopic Objects;* by Dr. CARPENTER, (Rep. Brit. Assoc. for 1847, Athen., No. 1028.)—Numerous specimens of Daguerreotype and other photographic copies of very delicate microscopic objects were exhibited. These were peculiarly beautiful, and were obtained by the use of the solar microscope, the object being thrown upon the paper or plate instead of upon the ordinary screen. The minute fidelity of these copies was far beyond anything which could be obtained by the artist; and the ease with which they were produced, particularly on photographic paper, recommended this application of the art to the attention of naturalists.

7. *On the Quantity of Electrolysis as affected by the Extent of the Sectional Area of the Electrolyte;* by W. R. GROVE, Esq., (Proc. Brit. Assoc. for 1847, Athen., No. 1028.)—The experiments here described were made two years ago, and were intended as the commencement of a series of researches on the influence of quantity in voltaic arrangements, both as regarded the *generating* and also the *conducting* portions of the circuit. A single cell of a zinc and platina diaphragm battery charged on the negative side with peroxyd of manganese and hydrochloric acid, has a more intense action and will decompose more water in a given time than a similar battery charged with nitric acid; but two or more cells of the former, arranged in series, are far inferior to a similar number of the latter, particularly if large electrodes be employed. This inferiority in the chlorine battery arises, I believe, from want of quantity in the electro-negative element: the chlorine is slowly liberated and much diluted by the liquid hydrochloric acid, while the nitric acid supplies an indefinite quantity of what we may term liquid oxygen. Thus the cathode is in the one case bathed by hydrochloric acid, and in contact with a comparatively small portion of chlorine, while in the other case it is covered to nearly its whole extent by oxygen; in other words, the sectional area of the efficient electrolyte is smaller in the first case than in the second. It is admitted that in metallic conductors the facility of conduction is directly as the sectional area of the conducting substance; but the problem is rendered more complex in electrolytes by the polarization or reaction occasioned by the liberated ions, and also by the quantity of the efficient chemical ingredients contained in the electrolyte, whether they act directly as ions or secondarily by absorbing or preventing the liberation of the cathions at the cathode. Dr. Faraday, in his 'Researches,' has shown that separate pairs of electrodes interposed in the same circuit, yield the same amount of gas whatever be their size; and this result has been misinterpreted by many, and regarded as establishing that the size of electrodes with regard to that of the battery plates makes no practical difference in the amount of gas liberated. From the great practical experience which the application of voltaic electricity to the electrotype and its kindred arts has promoted, this error has now for some years been removed. I believe I was the first to point out the necessity of electrodes equal in area to the battery plates in order to yield the full

amount of gas which a battery is capable of yielding; and at the Royal Institution in the year 1840, I showed a voltameter constructed on this principle, which yielded mixed gas from a battery of four square feet surface, at the rate of 110 c. i. per minute. The voltameter used in these experiments was one which M. Gassiot caused to be constructed upon a suggestion of mine, and which consisted of five pairs of plates, each exposing to the other eight square inches of surface. Any number of these plates could be thrown into action at a time, so that excluding the outward sides of the exterior electrodes, the sectional area of the electrolyte would be 8..8+8..16+8, and so on up to 72 square inches. The diminution of the sectional area of the electrolyte in the battery occasioned by the porous cells, was ascertained by first charging a given battery with sulphate of copper without any porous cell, ascertaining the amount of decomposition per minute, and then placing in the battery the porous cells, which had been previously soaked in the same solution of copper,—again decomposing, and calculating from the difference the diminution of area. The following is the table of experiments made with that view—and which will in great part explain itself:—

*Experiments on Relative Sizes of Electrodes.—September 24th, 25th, 26th, 1845.*

| No. of Cells of N. A. Battery in series. | No. united in quantity. | Surface exposed of Battery each plate. | Surface exposed of Electrodes in sq. inches. | Quantity of Gas in c. i. per minute. |
|---|---|---|---|---|
| 1 | 1 | 8 | 8 | A trace |
| 1 | id. | 8 | 72 | id. |
| 2 | | 8 | 72 | 6·7 |
| | | | 32 | 6 |
| | | | 8 | 5·2 |
| | | | 1 | 2·8 |
| | | | Wire | 0·9 |
| 2 | 4 | 32 | 72 | 20·5 |
| | | | 64 | 20·5 |
| | | | 56 | 20·3 |
| | | | 48 | 20 |
| | | | 40 | 20 |
| | | | 32 | 19·4 |
| | | | 24 | 18·8 |
| | | | 16 | 16 |
| | | | 8 | 12 |
| | | | 1 | 3·5 |
| | | | Wire | 1 |

*Remarks.*—Battery in these experiments charged with nitric acid, sp. gr. 139, sulphuric acid, 1·22, or 1+4 water.

Dr. Faraday remarked on the importance of this investigation, and its application to the principles of electro-telegraphic communications, now that the discharging current was to be made through the earth.

8. *On a new theory of the Polarization of Light;* by Prof. Challis, (Proc. Brit. Assoc., Athen., No. 1028.)—In this theory *ether* is regarded as a continuous fluid substance, and is treated mathematically on hydrodynamical principles. By means of a new general equation in hydrodynamics, which the author has discovered, he shows that a filament of the fluid may continue in agitation without lateral spreading, and that motion may be propagated along it uniformly, provided the motion consist of vibrations partly longitudinal and partly transversal,

following the law of sines. Such a filament of motion is supposed to correspond to a ray of light. The sensation of light is due to the *transverse* vibrations. In a ray of common light the transverse motion is in planes passing through the axis of the ray, and is alike in all directions from the axis; in a plane-polarized ray, the transverse motion is in planes not passing through the axis; and in an elliptically polarized ray, the transverse vibrations are elliptical. Prof. Challis has extended his theory to the phenomena of double refraction, by a method which involves a new theory of the *dispersion* of light. He finds the surface of elasticity to be that of an ellipsoid; which is not in accordance with Fresnel's theory of double refraction. The equation of the wave-surface is, however, the same as in Fresnel's theory.

9. *Observations on the general Nature and Laws of Electrical Attraction;* by Sir W. S. HARRIS, (Proc. Brit. Assoc., 1847, Athen., No. 1029.)—The author commenced by a brief account of the theory of electricity resorted to by the French philosophers, and then proceeded to notice some physical facts which appeared to invalidate this theory; —amongst others, the electrical condition of a well-insulated body in a space nearly void of resistance, and which if preserved at a considerable distance from conducting matter maintained a charge, as well as under ordinary circumstances. The author, by a careful process, had been enabled to preserve the electricity of a small sphere in an exhausted medium for a very considerable time—many days. In conveying a charge to a common electrical jar it might be proved that equal quantities were received into it, in equal times, until there was a sort of overflow; being more analogous to the filling a vessel with an unelastic fluid such as water, than the condensation of an elastic fluid such as air. The action of the proof plane and the balance of torsion, as employed by the celebrated philosopher, Coulomb, was next adverted to. Here the author endeavored to show that great difficulties arose in deducing accurate results, inasmuch as the proof plane could not be considered as an element of the surface, and any electrometer acting on the principle of repulsion was liable to great uncertainty, and that hence deductions as to the particular distribution of electricity on the surfaces of bodies were inconclusive. It might so happen that the distribution may be uniform, and yet a proof plane come away more highly charged from one point than from another. The author called attention to an experiment of the celebrated Volta, who found that an electrical charge reposed more quietly on a long rectangular parallelogram than on a square, although the areas of the surface were the same. It was to be regretted, on account of the received mathematical theory of electricity, that all our experimental evidence relative to the distribution of a charge on the surface of conductors rests upon experiments with the proof plane, or some other body brought into contact with the given conductor and subsequently removed from it. The author, by a new method of experiment, had shown that the intensity of a charged surface of any rectangle was the same as when rolled up into the form of a cylinder, the quantity of electricity being the same—and that the intensity of a circular area was the same as that of the sphere into which we might conceive it to be transformed. An electrometer, depending on the attractive forces exerted between a

charged and neutral plane, was here exhibited to the Section, and was said to be susceptible of great accuracy in measurements of this kind. The author supposes every case of electrical attraction to resolve itself into the conditions of the Leyden experiment, and to be a simple case of electrical charge obtained by the opposition of two conducting surfaces with an intervening nonconducting medium; and it is well known that in the electrical jar the charge is not dependent on the thickness of the coatings but on their extension. If we could suppose a single body only in the universe—and to be charged with electricity—there appears no reason from experiment to suppose *à priori*, an unequal distribution upon it, be the form what it may; but if we conceive a second body to be called into existence, then the action termed electrical induction arises between the two, which is again reflected back by the second body upon the first; and on a space void of resistance this induction, however small, would cause an electrical current to flow through a space however great; but if a resisting nonconducting medium be interposed between these bodies, then we have to consider the action upon the interposed particles, and we have immediately a case of charge between the opposed surfaces of the two bodies,—and which will be greater in proportion to the amount of induction or electrical disturbance of which the previously neutral body is susceptible. In this way we may consider any two conducting bodies when opposed to each other as forming the coatings to an intermediate mass of air, and these are all the conditions we have to consider. In the case of two spheres opposed to each other, one insulated and charged with a given quantity of electricity, the other uninsulated and free, the determination of the laws of the attractive force was simple and the problem easy of solution, without any complicated consideration of an hypothetical distribution of the electricity upon the spheres and conductors connected with them;—we had, in fact, a chargeable system, with convex coatings. We have only to consider the opposed areas. Here, in whatever way the primary forces between the surfaces may be conceived to exist, they are finally reduced to an action between opposite and similar points, depending on the engagement of opposed positive and negative forces, by which an exclusive action between certain points is established. The attractive force between the spheres or rather opposed hemispheres, is as the number of attracting points, and inversely, and as the squares of the distances inversely; we can hence determine the position of two points $q$ $q'$ within the surface of each opposed hemisphere in which we may conceive the whole force to be collected, and to be the same as if derived from every point on the surface. The whole force will vary as the squares of the distances between these points inversely; so that a unit of force at a unit of distance between the nearest points of the spheres being given, it is easy to assign or predict the force at any other distance at which the intermediate air can become charged. The following formula was given by the author for determining the distance of the points $q$ $q'$ within the hemisphere: $z=\frac{(a^2+2ar)^{\frac{1}{2}}-a}{2}$. In which $z$ is the distance of the point $q$, $a$ the distance between the nearest points of the spheres, and $r$ the radius. When both hemispheres are equal, the whole force will

vary as $\frac{1}{a\,(a+2r)}$. As the distance between the spheres increases, the points $q\ q'$ recede from the surface, and would finally coincide with the centres of the spheres; which would limit the distance at which a charge could possibly occur. The author exhibited to the Section the striking agreement of the calculation with experiment by means of this electrical balance: consisting of a delicate scale-beam, with a duly poised suspended sphere. The weights requisite to balance the force between this sphere and a second sphere placed beneath it, and charged with a given quantity of electricity, were predicted with great precision. In the course of this paper some magnetic experiments were exhibited, illustrative of the action of the forces between similarly placed and opposite points. The author observed that every kind of case in ordinary electricity could be easily and simply investigated upon these principles; and that without the air between conductors could become charged, no attractive force would be apparent, and this would of course limit the distance at which such force could exist. It has been shown by Faraday, that with the same constraining power, induction takes place more readily, or with more difficulty, as the extent of the intervening dialectric particles is diminished or increased. We might have electrical currents in a space devoid of resistance; but without an interposed dialectric medium it is doubtful whether those phenomena indicative of attraction between the bodies would exist.

## II. Mineralogy and Geology.

1. *On an Amorphous Boracite;* by Dr. M. Karsten, (Rep. Brit. Assoc., for 1847, Athen., No. 1028.)—When boring for rock salt at Neusalzwerk, in the neighborhood of Minden, in Prussia, at the depth of about 1,400 feet, a bed of amorphous boracite was found, of which specimens were brought out by the boring apparatus. The chemical analysis, which proves that the composition of the amorphous mineral is exactly the same as that of the well-known crystallized body, was made by Dr. Karsten in Berlin, particulars of which may be seen in the monthly reports of the Berlin Academy. It seemed to him interesting to examine if that uncrystallized species would show the pyroelectric quality which in so high degree is to be seen in boracite crystals. Sir D. Brewster has pointed out a way by which the pyroelectric quality of pulverized tourmaline may be shown. By heating that substance the fine particles cohere together, and show that a polarization has taken place in them. The same phenomenon is to be seen in the particles of the amorphous boracite by pulverizing and heating it on a metallic plate. These boracite particles show by their pyroelectric properties that they must be crystallized, although by microscopic examination the crystallization cannot be discovered. The conclusion must be, that the difference between the crystallized and the amorphous states cannot be exactly determined, since the microscope shows in this case no crystallization where the pyroelectricity is a proof that we must suppose a crystalline structure.

2. *On Sulphato-Chlorid of Copper, a new Mineral;* by Prof. Connell, (Proc. Brit. Assoc., 1847, Athen., No. 1027.)—Amongst some

minerals which were lately put into my hands by Mr. Brooke for chemical examination, there was one which I found to consist of sulphuric acid, chlorine, copper, and a little water. Although I had not enough material to determine the proportions of the constituents, there can be no doubt that it consists of sulphate and chlorid of copper, with a little water. It occurs in small but beautiful fibrous crystals; which, according to Mr. Brooke, are hexagonal prisms, having the angles replaced,—and thus belong to the rhombohedral system. Their color is a fine blue,—pale when the fibres are delicate, but much deeper where they become thicker. Lustre, vitreous. Translucency considerable. Locality, Cornwall. The mineral is associated with arseniate of copper. Ten specimens are at present known; one is in the British Museum.

3. *On the Geological Structure of Barbadoes, and on the Fossil Infusoria, described by Prof. Ehrenberg, from the Tertiary Marls of that Island;* by Sir R. H. Schomburgk, (Proc. Brit. Assoc, 1847, Athen., No. 1028.)—Barbadoes is about twelve miles in length from north to south; about one-seventh part, forming the district of Scotland, consists of tertiary sandstones and limestones, rising to the height of nearly 1,200 feet above the sea. Over the rest of the island raised coral reefs cover the entire surface, which is divided by vertical walls of coral rock, some of them nearly 200 feet high, into six terraces, indicating as many different periods of upheaval. In the lowest of these terraces, fifteen or twenty feet above high water, Indian hatchets have been found in the reef, showing that the last movement had taken place within the human period. The shells found at the height of 150 and 300 feet above the sea still live upon the adjacent coast. In the southern part a well had been dug to the depth of 240 feet through compact coral rock. The highest part seems to have been the centre of the elevating force: from this point ravines, some of them 250 feet in depth, radiate in all directions towards the sea. The tertiary rocks of the Scotland district are more or less inclined, and sometimes vertical, or contorted. The marl beds, which form the greater part of the series, are several hundred feet thick. Bitumen, bituminous coal and sandstone, clays and ferruginous sands, are also found at Mount Hillaby and Springfield. Burnt Hill, near Conset's Bay, is reported to have been set on fire accidentally, and to have continued burning for five years. Slags are found on the surface bearing distinct marks of fire; and sandstone, containing bitumen and mineral oil, abound in the neighborhood. The summit of Bissey Hill, 986 feet above the sea, consists of silicious limestone, containing teeth of two species of shark (Lamna and Odontaspis), spines of Echini, and shells, one of which (*Scalaria Ehrenbergii*) is considered by Prof. Forbes to belong to the miocene period. In the white marls of the Scotland district, M. Ehrenberg has discovered the silicious skeletons of nearly 300 species of microscopic infusoria. These belong to a group called Polycistina by M. Ehrenberg, and to fifteen genera found hitherto in the marls of Sicily, at Oran in Africa, in Greece, in the tripoli of Richmond in Virginia, and in Bermuda; some of them are forms now living in the North Sea, and at the bottom of the sea near the South Pole. Prof. Ehrenberg remarks, that whilst phosphate of lime is the most important

element of the bones of the vertebrate animals, and carbonate of lime the chief material is the skeletons of the molluscous animals and zoophytes, silica is almost peculiar to these minute races of infusoria. Some of the marls in which these silicious animalcules are found contain a large admixture of pumice, giving it the character of volcanic tufa.

4. *Exploration of the Volcano Rucu-Pichincha, (Quito;)* by MM. Seb. Wisse et Garcia Moreno, during August, 1845, (abridged from the Comptes Rendus, 1846; Quart. Jour. Geol. Soc., No. 10.)—Pichincha is situated eleven miles in a straight line W.N.W. from Quito: its sides, which are covered with vegetation to the height of 12,116 feet, are furrowed by deep ravines. All the part above, called the 'Arenal,' is covered with sand and pumice, and is inclined at an angle of 25° to 35°.

The authors having ascended the Arenal to the height of 1542 feet, reached the edge of the crater, which is broken down on the south and on the west, and found the cavity of the volcano to consist of two funnel-shaped craters, apparently resulting from two sets of eruptions. They descended into the eastern crater, a depth of 1050 feet, and found it to consist simply of a vast ravine, at the bottom of which was the bed of a torrent, always dry except during rains.

The western crater is nearly circular, and regularly funnel-shaped: at the bottom is a small plain, through which flow two torrents, which unite near the western opening of the crater. On the western side of this plain rises a hill or cone of eruption, whose height is about 260 feet above the mean level of the bottom of the crater, and its diameter about 1476 feet. This hill is embraced by the two torrents, so as to form a kind of peninsula during heavy rains. It is far from perfectly conical at present, being covered with irregular heaps of stones, and fissured in all directions, proving the violence of the convulsions it has been subjected to in recent times. The volcanic vents, whether active or extinct, are all situated in this cone of eruption; not the slightest trace of one being found elsewhere. They are arranged in nearly circular groups of different dimensions, some of them attaining a diameter of 82 feet. There are in all nine of these groups, six in activity and three extinct, all situated in those parts of the cone which appear to have been most recently convulsed. The cavity at the eastern foot of the cone is 150 feet in diameter and 65 feet in depth, and contains three groups, two at the sides in activity, and one extinct in the centre. These are the first that are met by a person descending from the east, and are the only ones seen in fine weather from the summit of the eastern crater. At a short distance to the right of this cavity is a fissure about four inches in breadth, from which issue vapors; and on the left a single vent occurs in the midst of vegetation, which grows luxuriantly within a yard of the orifice.

In mounting the cone two more groups of active vents are reached; and finally at the summit, the most considerable and imposing group of all. It contains nearly forty active vents within a cavity 260 feet in diameter and 65 feet in depth, and exhibits proof of tremendous exertions of force. Cubical masses of rock, upwards of 12 feet in the side,

are thrown about in the utmost confusion; while between their interstices the most suffocating vapors arise.

Lastly, at the foot of the cone are found two more groups of extinct vents. The total number of active vents is about seventy.

Vapors also find their way through the loose soil, which consists of ashes, sand, and sulphur: their odor was that of burnt sulphur and of rotten eggs; from which it is to be presumed that they consist of a mixture of the sulphurous and hydrosulphuric acids. The authors next mounted with incredible labor to the summit of the volcano, whose crest is serrated with sharp pyramidal rocks, resembling the teeth of a saw. The inner walls near the top consist of detached blocks and rocks of all sizes; and lower down, of sand and soil with occasional patches of vegetation. The rocks blackened by time, the profound obscurity, and the vast columns of smoke issuing from an abyss 2460 feet in depth, are described as forming a majestic and terrible scene.

The authors give the following reasons for believing the eastern crater to be the more ancient. It contains no traces of volcanic fumeroles, and its cone of eruption has entirely disappeared; its interior walls are but slightly inclined; and the ridge which separates the two craters, though gently inclined towards the eastern crater, is cut off almost perpendicularly towards the western. The trachytic rocks of the eastern crater are covered over with sand and pumice, which have evidently been ejected from the western. The eastern crater burst forth near the summit of the ancient Pichincha, and the western on its side.

The later eruptions of Pichincha have produced nothing but pumice, that being the only rock visible at the surface. Below the Arenal, the sides of the mountain are covered with vegetation, the surface being composed of soil, sand, and pumice, without any débris which can be attributed to recent convulsions. The few masses of rock which pierce the vegetable crust are probably part of the interior stony structure. Yet the eruptions which caused the present craters must have been tremendous: solid rock which once formed the summit of Pichincha and the matter thrown from the interior must have reached immense distances, while violent earthquakes must have desolated the neighboring country. Had these been witnessed by man, tradition ought to have preserved the memory of them. But according to the historian of Quito, previous to the eruption of 1539, Pichincha was not known to be volcanic; the traditions of the Indians being absolutely silent on the point. The authors think it therefore probable that the eruptions which caused the present craters took place before man inhabited this part of the Cordilleras. The fumeroles of the present cone must also have been obstructed during a great lapse of time; otherwise the Indians must have noticed great columns of smoke, such as now rise from it. The only known eruptions in 1539, 1577, 1587 and 1660, have all issued from the existing cone; and to this epoch must be referred the blowing away of the matter which choked the old vent, and the formation of the present cavities.

But in spite of history and tradition, it is impossible to believe that the vast blocks, more than 12 feet in diameter, which cover part of the plain of Iña Quito, distant 3½ leagues, can have been thrown out by the eruption of 1539. There are no traces of such recent eruptions on

the sides of Pichincha, and the present cone is far from being considerable enough to have furnished such a vast quantity of projectiles. Those which were thrown at angles less than 45° would strike against the inner walls of the crater, and roll back again into it; those only which were thrown at greater angles, and with force enough to rise 16,000 feet above the plain of Quito, could reach their present positions; and although this is not physically impossible, yet it is contradicted by the appearances of the later eruptions, which have clearly been of a very tranquil description.

The authors consider as equally fabulous, a tradition that the eruption of 1660 was accompanied by showers of incandescent rocks, which are said to have fallen on all sides, but of which not a vestige is now to be seen. J. C. M.

5. *Count Keyserling's Geology of the Northeastern Extremity of Russia in Europe;* by Sir R. I. MURCHISON, (Proc. Brit. Assoc., 1847, Athen., No. 1028.)—Sir R. I. Murchison exhibited the new work, entitled, "*Wissenschaftliche Beobachtungen auf einen Reise in das Petschora-land*,"* and explained its value in completing the acquaintance of geologists with the great northeastern angle of Russia in Europe, which is watered by the river Petschora. The geographical and astronomical observations in this expedition (to a region previously known only imperfectly to the Russians through the traders in fur) are by M. P. von Krusenstern, of the Imperial Navy. The geological outline of the present work (executed in 1843) was communicated to Sir R. I. Murchison previous to the publication of the volumes on the "Geology of Russia and the Ural Mountains," and constitutes one of the chapters of that work; but the object of this communication was to call attention to the additions which had appeared: first, in regard to the physical and geological delineation of this wild country in two maps; and, secondly, to the numerous plates (twenty-three in number) of the organic remains of the Silurian, Devonian, Carboniferous, Permian, and Jurassic systems, occurring in a hitherto unexplored region which extends over near 11 degrees of latitude; viz. from 60° to 71° N. lat., and 25° long., including the northernmost range of the Ural Mountains. Sir R. I. Murchison stated that although the eastern flank of that chain had been touched upon at one or two points by the authors, and notably in N. lat. 65°, enough had only just been done by them in this respect to connect, in an approximate manner, the structure of the northern end of the chain with that previously described: all this rocky territory, extending 3° and 4° of latitude beyond the limits of arboreal vegetation, is now under the survey of a distinct expedition, commanded by Col. Hoffman, and sent out under the auspices of the Geographical Society of St. Petersburg. The chief geological interest attached to the work of Count Keyserling, (in addition to the points alluded to,) is the determination of an axis of palæozoic rocks constituting the Timan Ridge, which, branching off from near the Ural Mountains in lat. N. 62°, trends in a N.N.W. direction to the left bank of the Petschora to the bay of Techeskaya, and is prolonged into the promontory of Kanin-

* This work consists of a 4to volume of text, published in German at St. Petersburg in 1846, with 23 elegant 4to plates of fossils, and two maps.—J. D. D.

Nos in lat. 68° 45′. This ridge, divergent from the meridian direction of the Ural Mountains, but parallel to their northern extremity, seems to form a part of the great girdle of palæozoic deposits which wrap round the crystalline nucleus of Lapland and Scandinavia, of which the Baron Leopold von Buch, by his description of the fossils collected there, has recently determined an important fragment of carboniferous age in Bear Island near Spitzbergen, on the north-western flank of Scandinavia.

6. *On the Fossil Vegetation of Anthracite Coal.*—Mr. J. E. Teschemacher, at the recent meeting of the American Association of Geologists and Naturalists, read a paper on this subject, confining his observations to the remains of vegetation found in the *body* of the coal, apart from that in the accompanying shales. The principal points of the memoir were that, the remains of the larger forms of the coal epoch, as well as of the smaller plants, were abundant in the coal, contrary to the usual opinion. Specimens were exhibited from the interior of the coal, showing the external and internal parts of plants—the vessels—the leaves—the seeds, &c.

Since the meeting, Mr. Teschemacher has continued his investigations, and has communicated in a letter to one of the editors the following results.

1st. What I considered as vessels were said to be mere marks of sliding of the coal. Prof. Bailey prepared a specimen of this, by his method, and told me that if I found vessels there, my proposition was correct. Examined by Agassiz and myself, with his large Oberhauser, it turns out to be *nothing* but a *mass* of perforated vessels, as clear and distinct as if they were recent. Mr. Agassiz observed, "one moment suffices to remove every doubt on the subject."

2nd. What I considered as fossil seeds, were said to be mere peacock-eye coal; the dark carbonaceous centres of these seeds which I held to be carbonized cellular matter, was thought to be a mere mistake and the seeds imaginary. I have since discovered them with distinct and clear apparently spinous appendages. Mr. Agassiz thinks the seed a Samara, and I have found sufficient quantity to pick out the carbonaceous matter from the interior with a fine needle—decarbonize it in a clean platina crucible over a spirit lamp, with every possible precaution to prevent any foreign substance mixing therewith; on examining this with the Oberhauser, 700 diameters, Mr. Agassiz shewed to Dr. Gould and myself the cells as clear and plain as possible; it is a mass of cellular matter as I stated. You may of course imagine the extreme tenuity of the parietes of cells of seeds when decarbonized, and the difficulty of those less experienced than Agassiz in the microscope in managing the subject—he feels quite convinced of their being fossil seeds. The nature of the genus of plants must require further examination.

3rd. The smooth glossy surfaces which I considered the external parts of large plants rendered smooth by intense pressure, were said to be nothing more than slickenslides. My position here is proved much more easily than in the other cases, by specimens passing gradually from the smoother through different degrees of protuberance, (all still smooth and polished,) until we arrive at the full form of the Lepidodendron. Nay more, I have found the parallel lines (channels) which are

on the slickenslides, also on the perfectly formed Lepidodendra. The correctness of my views here I could prove to the most skeptical.

The discoveries still to be made on this subject are numerous and important, and I doubt not that the investigation of the coal itself will soon solve the doubts hitherto existing in the comparison of the coal fossils with recent plants.

I will merely add, that I have found quite distinctly the impression of the cellular cuticle of some of these plants, which of course cannot be seen in an impression on shale, the grains of the sedimentary matter being as large as the surface of the cells; but on the pasty mass of coal the impression is perfect.

## III. Botany and Zoology.

1. *Description of a supposed new species of Columba, inhabiting Mexico;* by George A. M'Call, (Proceed. Acad. Nat. Sci. Philad., July, 1847.)—*Columba solitaria.*—Length 13 inches 9 lines. Alar extent 23 inches. Wing, from the flexure, 7 inches, 5 lines. Tarsus 1 inch; middle toe 1 inch, 2 lines; first toe 9 lines, and longer than the third; nails light flesh color; feet and legs deep red. Iris dark orange. Bill above, 1 inch, 1 line, but feathered to within 5 lines of the tip; reddish near the base, whitish near the tip. Head chocolate-blue. Throat chocolate-white. Neck and breast blueish-chocolate with brilliant reflections. Back, belly, flanks, underwing-coverts and greater exterior wing-coverts light red color, the last faintly bordered with white. Lesser wing-coverts chocolate red, forming a bright shoulder spot of elliptical shape. Quill feathers dusky, tinged with lead color on the outer vanes. 3rd primary longest. Upper and under tail-coverts blueish-lead color. Tail 5 inches; slightly rounded; of twelve feathers; dusky.

Individuals of this fine species, which in general contour, resembles *Columba Œnas*, were found on the Rio Grande, from Matamoras to Camargo; these were shy, and only met with at intervals. They were again observed on one or two of the smaller water courses between the former place and Victoria, but never in flocks; nor were more than half-a-dozen seen anywhere in a single day while hunting over large extents. Their haunts were in the neighborhood of running streams or very large ponds of clear water: here four or five might be found scattered over some 20 or 50 acres; thus showing little sociability even on their feeding grounds. But most frequently he is found alone, perched near the water, or with rapid wing shaping his solitary course across the extensive waste. His flight is extremely bold, as he pitches in wide irregular *zig zags* through the air, with a velocity scarcely to be surpassed. The meat for delicacy of flavor is not excelled by any of the family.

2. *Basilosaurus*, (communicated by Prof. Agassiz, from a letter recently received from M. A. Retzius.)—The following is an extract from a letter from Prof. J. Müller to Mr. A. Retzius, dated Berlin, March 24, 1847.

"The *Hydrarchus*, *Koch*, found in the tertiary formation in Alabama, is identical with Harlan's *Basilosaurus* and Owen's *Zeuglodon cetoides*."*

* Phocodon, Agassiz. Squalodon, Grateloup, in Leonhard and Bronn's Jahrbuch für Mineralogie, 1841, p. 830.

The crowns of the teeth, with which Owen was not acquainted, have a great resemblance to those of the seal; in the maxillary teeth they are cutting and many pointed; most of the maxillary teeth have double roots, but the anterior has, as in the seals, only a single root. In the anterior part of the jaw are found conical curved teeth, viz. an incisive and a canine, at least this is the case with the under jaw.

"As such teeth as those which are found in the Hydrarchus, occur in the tertiary formation in Malta, we may conclude that this animal belongs likewise to the tertiary formation of that island.

"I think I can positively show that the Hydrarchus is not a reptile, but a mammal belonging to a peculiar extinct family. It has the ear formed as in the mammals, viz. a helix, and a tympanic bone as in the whales. It has moreover two occipital condyles, and in the whole formation of the cranium no trace of reptile structure occurs, but on the contrary every thing is as in mammals.

"The vertebral column is very peculiar in its structure. The cervical vertebræ, probably more numerous than in any other mammal, are without perforations in their transverse processes; the ribs are only attached to the transverse processes of the vertebræ; at the central and posterior part of the column, the bodies of the vertebræ are unusually long, and must both at the anterior and posterior part of the extremities have been cartilaginous, inasmuch as we find here beneath the bony shell a mass of pure stone, while the central part of these vertebræ consists wholly of bone."

3. *On the History of the Dodo and other allied species of Birds;* by H. E. Strickland, (Athen., No. 1029.)—He showed from historical data that each of the three islands of the Indo-African Ocean—Mauritius, Rodriguez and Bourbon—was originally inhabited by peculiar species of brevipennate birds, all of which were speedily destroyed by the early colonists. Mauritius was the birthplace of the Dodo:—the first notice of which was not, as erroneously stated, by Vasco de Gama, (who never visited Mauritius,) but by Van Neck, a Dutchman, in 1598. Several successive voyagers mention the bird, down to Cauche in 1638; and in the latter year a live specimen was brought to London, and was described by Sir Hamon Lestrange. The *pictorial evidence* respecting the dodo consists of four oil paintings:—one in the British Museum, without the artist's name; one at the Hague, and another at Berlin, by Roland Savery; and one at Oxford, by John Savery, his nephew. All these are evidently from one design,—and may have been drawn from a specimen which Van Neck brought to Holland. The *osteological evidences* of the Dodo consist of the foot in the British Museum, the head and foot at Oxford, and a head lately discovered at Copenhagen. The three former specimens were exhibited; and a cast of the latter had also been sent for the meeting; but was detained by the vexatious formalities of the London Custom House. The Oxford head and foot have been recently dissected; and from the characters thus exposed it is certain that the Dodo was not related either to the gallinaceous birds, the ostriches, or the vultures, as others have conjectured—but is closely allied to the pigeons. With the exception of its short wings, it approaches greatly to the *Trerons*, or fruit-pigeons; and still more to the *Didunculus*, a kind of pigeon from the Samoan

Islands, of which the only specimen in Europe was exhibited at the meeting. The author supposes that the Dodo fed upon the cocoa-nuts, mangos, and other fruits which in tropical forests fall from the trees at all seasons of the year. The lecturer then drew attention to the island of Rodriguez, visited in 1691 by Leguat; who has given a description and figure of a brevipennate bird which he calls the *Solitaire*. Several bones of this bird from the Museums of Paris and of Glasgow, were on the table; and a comparison of them with those of the Dodo clearly proved that the "Solitaire" was an allied, but distinct species,—longer legged than the Dodo, and related, like it, to the pigeons. It was next shown, from the narratives of several voyagers, that the island of Bourbon was also formerly inhabited by two species of short-winged birds of the same abnormal group as the Dodo and the Solitaire. Unfortunately, we have as yet no osseous remains of these birds from Bourbon:—but they might doubtless be procured from the caves and alluvial deposits of that island; and by similar researches in Mauritius and Rodriguez, the entire skeletons of this remarkable family of extinct birds might be reconstructed.

4. *Ehrenberg on the Sirocco-dust that fell at Genoa on the 16th May*, 1846, (Quart. Jour. Geol. Soc., No. 10, from the 'Berlin Monats-Bericht,' for 1846, p. 202–207.)—The microscopic analysis of this dust produced 22 polygastrica, 21 phytolitharia, together with the pollen of plants and the spores of Puccinium. The varieties of dust which since 1830 have fallen in the Atlantic Ocean, as far as 800 sea miles west from Africa, on the Cape Verd islands, even in Malta and Genoa, which the author has had an opportunity of examining, all agreed in the following particulars:—1st, they are all ochre yellow, never grey, like the dust of the Khamseen in the north of Africa; 2nd, the color is produced by iron oxyd; 3rd, from one-sixth to one-third of their mass consists of recognizable organic parts; 4th, these are either siliceous polygastrica and phytolitharia, or carbonaceous but uncarbonized portions of plants, or calcareous polythalamia; 5th, the greater number of the ninety species already found equally occur in the most widely separated of the places just named; 6th, the most numerous forms are every where land and freshwater productions; yet some marine animalcules are constantly mixed with them; 7th, in no case were dried up, living species (except the pollen and spores), nowhere melted, calcined, or carbonized forms among them; 8th, even the dust of Genoa, although brought there by the Sirocco, exhibited as little as any of the former, characteristic African forms, which yet are found in every small portion of mud from Africa; on the contrary, one of them, *Synedra entomon*, is a decidedly characteristic South American form. It is remarkable that the few (2?) European observations hitherto made have always fallen on the 15th and 16th of May. The author concludes with the question, whether there is not a current of air uniting Africa and America in the region of the trade-winds, which is occasionally, and especially on these days, turned towards Europe, and brings that dust along with it? J. N.

5. *A Fact respecting the Habits of Notonecta glauca;* by Prof. Forrest Shepherd, (communicated for this Journal.)—In the evening twilight of a pleasant day in September, 1846, Sir George Simpson en-

camped for the night, on his route from Red River to the head waters of the Mississippi, in the vicinity of latitude 48 degrees North and longitude 95 or 96 degrees West from Greenwich. While supper was preparing, he perceived something falling on his hat like drops of rain; but as there were no clouds to be seen, presumed it could not be rain. On looking on the ground near the fire, he saw distinctly that the falling substance instead of being rain was a small winged insect, which, although unable to fly had yet life and motion. The number rapidly increased so as to give great annoyance by falling into the frying-pan and supper vessels; and continued until the ground was covered by the shower. On the following morning, Sir George ascertained that this extraordinary shower extended at least from twenty-five to thirty miles in the direction he was travelling. No information has been received as to its extent in other directions. It was observed that soon after the shower, the weather changed suddenly from warm to cold. It is therefore probable that the whole of this immense swarm of insects encountered the cold current, and were paralyzed and precipitated thereby. They all died soon after falling. Specimens of these insects were collected by the attendants of Sir George, from whom I received them. In no instance, however, were they seen to revive after coming into a warmer atmosphere. Not being able to recognize this species, I took the specimens to Professor Bachhofner, of the Royal Polytechnic Institution of London, who at once declared them to be the "*Notonecta glauca*," a species of aquatic diptera, well known in Europe.

Other specimens were given to Dr. Le Conte, of New York, from whom the scientific community will probably hereafter receive a more particular description through the columns of the American Journal.

Western Reserve College, Hudson, Ohio, July 27, 1847.

6. *On the Diatomaceous Vegetation of the Antarctic Ocean;* by Dr. J. Hooker, (Proc. Brit. Assoc., 1847, Athen., No. 1028.)—The author found the Diatomaceæ in countless numbers between the parallels 60° and 80° south, where they gave a color to the sea, and also to the icebergs floating on it. The death of these bodies in the south Arctic Ocean is producing a sub-marine deposit, consisting entirely of the siliceous particles of which the skeletons of these vegetables are composed. This deposit exists on the shores of the Victoria Land, and at the base of the volcanic mountain Erebus. Dr. Hooker accounted for the fact that the skeletons of Diatomaceæ had been found in the lava of volcanic mountains, by referring to the position of the Diatomaceæ deposits in relation to Mount Erebus,—which lie in such a position as to render it quite possible that the skeletons of these vegetables should pass into the lower fissures of the mountain, and then passing into the stream of lava, be thrown out unacted upon by the heat to which they have been exposed.

7. *Analogy between the Fossil Flora of the European Miocene and the living Flora of America;* by Prof. Agassiz, in a letter to R. I. Murchison, (Athenæum, No. 1023.)—"I think I made a lucky and quite an unexpected hit, by tracing the close analogy between the fossil Flora of the European miocene deposits (*molasse*) and the living Flora of the temperate parts of the United States of North America. The correspondence extends to all the types of organized beings. After

having seen the Chelydra alive in the swamps here, under the shade of trees analogous to those which cover the ancient soil of Oeningen, (so celebrated for its profusion of terrestrial and freshwater fossil remains,) I cannot help thinking that the climate could not have been tropical in Europe at the time when the strata of Oeningen were deposited. Again, I may observe that there is the closest affinity between the Flora of the Atlantic shores of North America and that of Japan; where we have the Megalobatrachus, the corresponding living type of the Andrias, or great fossil salamander of Oeningen. As I am unable to write a paper now, I would thank you to make these remarks known before I can publish them *in extenso*."

## IV. Astronomy.

1. *The New Planet* Iris.—The discovery by Mr. J. R. Hind of London, of another planet between Mars and Jupiter, is thus announced in his letter to *The Times*, published Aug. 18, 1847.

"*Sir*—In addition to the Berlin Maps, which we have revised, and in some instances corrected, Ecliptical charts of stars down to the tenth magnitude, have been formed for some of the hours of Right Ascension, which it is Mr. Bishop's intention to publish as soon as they are completed. On the 13th of August, I compared Wolfers's Map [Hora xix] with the heavens, and was surprised to find an unmarked star of 8·9 magnitude in a position which was examined June 22 and July 31, without any note being made. The mere existence of a star in a position where before there was none visible, would not have been sufficient to satisfy me as to its nature; because during an eight months' search I have met with very many variable stars,—a class which I believe to be far more numerous than is generally supposed. But on employing the wire micrometer we were enabled in less than half an hour to establish its motion, and thus to convince ourselves that I had been fortunate enough to discover a new member of the planetary system. It may appear to many of your readers rather bold to announce the existence of a new planet, from the detection of so small an amount of motion as $2^s{\cdot}5$ in R.A.; but such is the firm mounting of the large refracting telescope, and the perfection of the micrometers, (for which we have to thank Mr. Dollond,) that a far smaller change would have been sufficient to convince us as to the nature of the object in question. Mr. Bishop has fixed upon *Iris* as an appropriate name for the new planet; and we hope that astronomers generally will join with us in its adoption. The following are all the observations we have yet made.

| | Gr. m. t. | R.A. of Iris. | S. decl. |
|---|---|---|---|
| | h. m. s. | h. m. s. | ° ′ ″ |
| 1847. Aug. 13, | 9 39 46 | 19 57 30·38 | 13 27 21·5 |
| 13, | 10 37 24 | 19 57 28·41 | 13 27 27·6 |
| 14, | 9 23 58 | 19 56 38·30 | 13 29 14·0 |
| 15, | 9 0 39 | 19 55 47·64 | 13 31 4·3 |

*Mr. Bishop's Observatory, Regent's Park, Aug.* 17."

Mr. Hind subsequently communicated to the *Times* his first approximation to the elements of this planet, from an observation of Aug. 20, by Prof. Challis, and two taken by himself, Aug. 13 and 26, neglecting parallax and aberration.

| | |
|---|---|
| Mean long. 1847, Sept. 0, Gr. m. t., . | 356° 9′ 13″·3 |
| Long. of perihelion, . . . . | 26 9 48 ·5 } m. eqx. |
| " " ascending node, . . . | 251 41 14 ·5 } 1847·0 |
| Inclination, . . . . . | 4 37 22 ·1 |
| Angle of excentricity, . . . | 25 35 22 ·1 |
| or $e$, . . . . | 0·43192 |
| Log. semi-axis major, . . . . | 0·4598916 |
| Period in sidereal years, . . . . | 4·896 |

This orbit, as Mr. Hind observes, is remarkable for its great excentricity; and the period of revolution is longer than that of any of the other asteroids.

*Hebe* is the name given to the planet discovered by Mr. Hencke, July 1, 1847. (See p. 286 of this volume.)

2. *Comet of May* 7, 1847, (Astr. Nach., No. 603.)—Prof. Colla, at Parma in Italy, discovered, May 7, 1847, a faint telescopic comet in the constellation *Leo Minor*. D'Arrest of Berlin has given the following elements.

Perihelion passage, 1847, June 12$^{d}$·41336 m. t. Berl.

| | |
|---|---|
| Long. of Perihelion, . | 137° 41′ 33″·7 } m. eqx. |
| " " Asc. Node, . | 173 25 50 ·3 } 1847·0 |
| Inclination, . . . | 80 16 56 ·5 |
| Log. Perih. dist., . | 0·3257617 |
| Motion, . . . . | Retrograde. |

3. *Comet of July* 4, 1847.—In the *Comptes Rendus*, July 26, 1847, Mauvais gave the following elements (second approximation) of the orbit of the comet discovered by him July 4, 1847, (see p. 287, this volume,) viz.

Perihelion passage, 1847, Aug. 8$^{d}$·451318

| | |
|---|---|
| Long. of Perihelion, . | 247° 9′ 46″·7 } m. eqx. |
| " " Asc. Node, . | 338 8 45 ·4 } July 0, 1847. |
| Inclination, . . . | 83 27 25 ·9 |
| Perihelion dist., . . | 1·767552 |
| Motion, . . . . | Retrograde. |

4. *New Comet*, (Lond. Athen., Sept. 11, 1847.)—*M. Schweizer*, at Moscow, discovered a telescopic comet Aug. 11, 1847, between $\beta$ and $\theta$ *Aurigæ*. It was round and without tail. In 24 hours its R.A. diminished about 13 minutes of time, and its declination lessened about 10 minutes of space.

5. *New Comet*, (Boston Evening Transcript, Oct. 9.)—A telescopic comet was discovered by a lady of Nantucket, on the morning of Oct. 1, 1847, in the constellation *Cepheus*. It is now visible to the naked eye. Its position determined at the Cambridge Observatory, from comparisons with *zeta Draconis*, was

Oct. 7, 7$^{h}$ 56$^{m}$ 31$^{s}$, R.A. 17$^{h}$ 10$^{m}$ 56$^{s}$·2, and
N. Dec. 70° 1′ 18″; referred to M. Eqx. Jan 1.

6. *The New Telescope at Cambridge.*—The following letter from Mr. Bond, the Director of the Observatory at Cambridge, Mass., respecting the performance of the Grand Refractor recently mounted there, will be read with much interest.

Cambridge Observatory, Sept. 22d, 1847.

*Dear Sir*—You will rejoice with me that the great nebula in Orion has yielded to the power of our incomparable telescope.

This morning the atmosphere being in a favorable condition, at about 3 o'clock the telescope was set upon the Trapezium in the great nebula of Orion.—Under a power of 200, the 5th star was immediately conspicuous; but our attention was directly absorbed with the splendid revelations made in its immediate neighborhood. This part of the nebula was resolved into bright points of light. The number of stars was too great to attempt counting them; many were however readily located and mapped. The double character of the brightest star of the Trapezium was readily recognized with a power of 600.—This is "Struve's 6th star;" and certain of the stars composing the nebula were seen as double stars under this power.

It should be borne in mind that this nebula and that of Andromeda have been the last strong-hold of the nebular theory; that is, the idea, first thrown out by the elder Herschel, of masses of nebulous matter in process of condensation into systems. The nebula in Orion yielded not to the unrivaled skill of both the Herschels, armed with their excellent Reflectors.

It even defied the power of Lord Rosse's three-foot mirrors, giving "not the slightest trace of resolvability," or separation into a number of *single* sparkling points.

And even when, for the first time, Lord Rosse's grand Reflector of six-feet speculum was directed to this object, "not the veriest trace of a star was to be seen." Subsequently his Lordship communicated the result of his farther examination of Orion, as follows:—

"I think I may safely say, that there can be little if any doubt as to the resolvability of the nebula.—We could plainly see that all about the Trapezium is a mass of stars; the rest of the nebula also abounding in stars, and exhibiting the characteristics of resolvability strongly marked."

This has hitherto been considered as the greatest effort of the largest reflecting telescope in the world;—and this our own telescope has accomplished.

I feel deeply sensible of the odiousness of comparisons;—but innumerable applications have been made to me for evidence of the excellence of the instrument, and I can see no other way in which the public are to be made acquainted with its merits.

With sincere respect and esteem, I remain, Sir, your obedient servant, (Signed) W. C. Bond.

Pres't Everett.

## V. Miscellaneous Intelligence.

1. *Eighth Annual Meeting of the Association of American Geologists and Naturalists.*—This meeting was convened according to adjournment, at Boston, on the 20th Sept., and continued to the 25th. It was numerously attended by gentlemen of science from all parts of the country, and the presence of several Europeans of eminence added interest and value to the sessions. No official account of the proceedings has appeared, but from the daily journals we are able to give a

tolerably complete list of the papers read during the meeting. The most important step taken at this meeting was the enlargement of the sphere of operations in this association and a corresponding change of name—THE AMERICAN ASSOCIATION FOR THE PROMOTION OF SCIENCE is hereafter to be its designation, and it is designed to embrace all laborers in Physical Science and Natural History. Hitherto but few papers have been read on chemistry, natural philosophy, and general zoology, the title of the Association appearing to many to exclude these topics. A corresponding increase of valuable papers and collaborators it is anticipated will follow this desirable change.

The vacancy in the office of chairman, occasioned by the lamented death of Dr. Binney, was filled by the appointment of Prof. Wm. B. Rogers of Virginia.

*Papers read September 21st.*

On the Mississippi Bluff formation, near Natchez; by Col. B. L. C. Wailes, of Washington, Miss.

On animal torpidity; by Peter A. Browne, Esq. of Philadelphia.

On the fossil vegetation of Anthracite coal; by Joseph E. Teschemacher, of Boston.

On the structure of the Echinodermata; by Prof. Agassiz.

On certain new species of Fossil Mammalia from Illinois; by John L. LeConte, of New York.

*September 22d.*

On the remains of existing Marine Shells found in the hills of Drift and Boulders, in Brooklyn, N. Y.; by W. C. Redfield.

On the Structure of Anthracite Coal; by Prof. J. W. Bailey.

On the Animals which formed the Fossil Footmarks in New England; by President Hitchcock.

On certain relations of the Alkaline Earths; by Prof. E. N. Horsford.

On the Antiquity of the Indian Mounds; by E. G. Squier.

On the structure of Polyps; by Prof. Agassiz.

*September 23d.*

On the Mastodon; by Dr. J. C. Warren.

On certain Laws of Cohesive Attraction; by J. D. Dana.

[Mr. Dana's paper will be found in full, commencing on page 364 of this number.]

Letter from W. C. Bond, on the Resolvability of the Nebula of Orion.

On the Nebular Hypothesis; Prof. B. Peirce.

On a new species of Orang; by Dr. J. Wyman.

On the Geographical Distribution of Animals along the coast of New England; by Prof. Agassiz.

On the Cypress Swamps of Mississippi and Louisiana; by Dr. Dickerson.

Report on the Currents of the North Atlantic; by Lieut. Maury.

On the Fishes of Lake Winipissiogee; by Dr. Wm. Prescott.

On Claystone concretions; by Prof. C. B. Adams.

*September 24th.*

On the Natchez Bluff formation; by Dr. L. D. Gale.

On the Absorption of Carbonic acid; by Profs. W. B. and R. E. Rogers.

On the Languages of the Aborigines of the Southwest; by S. S. Haldeman.

On the Mounds of the Southwest; by Dr. M. W. Dickerson.

On the general results of Investigations in the Palæontology of the lower strata of New York; by James Hall.

On the Depth and Saltness of the Ocean; by Com. C. Wilkes, U.S.N.

On Heat; by Prof. Henry.

On the Taconic System; by Prof. Adams.

Report on the Taconic System; by Prof. L. Vanuxem.

On the Phenomena of Drift and Glacial action in New England; by Mr. Desor.

On the Drift of New England and the River St. Lawrence; by Prof. H. D. Rogers.

*September 25th, Saturday morning.—Final Session.*

On the Incrustations of Steam Boilers; by Prof. W. R. Johnson.

On the Structure of the Holothuridæ; by Count Pourtales.

On the Distribution of organic matter in forest and fruit trees; by Prof. E. Emmons.

Report on Trilobites, Crinoidea, &c., of New York; by J. Hall.

On the Organization and objects of the Smithsonian Institution; by Prof. Jos. Henry.

The Association adjourned to meet in Philadelphia in September, 1848.

Abstracts of the papers read and remarks made at the Association will be hereafter given in this Journal as far as they may be sent in by their authors.

2. *Iowa Meteorite*, (from a letter, from Joshua Barney, U. S. Agent, Dubuque, to J. J. Abert, Col. Topographical Bureau, Washington.)—The accompanying fragment of an aerolite fell at 3 o'clock in the afternoon of the 25th day of February, 1847, within seventy-five yards of the house of Daniel Rogers, nine miles due south of Marion, Linn Co., Iowa. The ground was covered with snow at the time it fell. Mr. Rogers heard a loud explosion in the air, and immediately ran to his door. He heard the stone, of which this is a piece, and several others, whiz through the air, and strike the ground, and saw the snow and dirt fly where this stone struck. The weight of the stone before it was broken, was forty-two pounds.

It is said that three more of the stones have been found, all of which are precisely similar in appearance, and nearly of the same weight of this—as it appeared before broken.

The explosion was heard distinctly by one of the surveyors who was engaged on the survey of the public lands, forty miles distant from Mr. Rogers' house.

Note.—The piece referred to was sent to Col. Abert, Washington. It weighs two lbs. eleven ozs.

3. *Supernumerary Rainbows;* by John Brocklesby, (in a letter to the editors, dated Hartford, Ct., Aug. 20, 1847.)—On the evening of the fifth of August of the present year, I beheld just at sun-down, a beautiful rainbow attended by the usual secondary, and two supplementary arcs. The primary bow formed, of course, a complete semicircle, and its tints were remarkably vivid. Within this appeared two supernumerary arcs, the three spectra being in contact with each other, throughout the whole extent of the primary bow.

Only two of the prismatic colors were visible. The red of the primary was succeeded by the green; then came the faint red of the first supernumerary bow; a dark interval next occurred, which was followed by the still fainter red of the second supplementary arc.

This singular optical phenomenon usually presents a succession of green and violet; or green and red arcs, alternating with each other, like those seen by Brewster in 1828; but that supernumerary bows are sometimes formed of a single hue, is evident from what has just been stated, and from the case detailed by Prof. Twining, who beheld, at Montreal, in September, 1823, three supplementary bows of a violet or dull red tint, unaccompanied by arcs of green.

4. *On some Recent and Remarkable Examples of the Protection afforded by Metallic Conductors against Heavy Strokes of Lightning;* by Sir W. S. Harris, (Proc. Brit. Assoc., 1847, Athenæum, No. 1027, July 3.)—The possibility of guarding buildings and other structures against the destructive effects of lightning, has been made a great question in practical science, from the time of Franklin to the present day; and it is of considerable public importance, seeing the frequent damage which occurs to our beautiful churches and other edifices by strokes of lightning, to bring this question completely under the dominion of induction, observation and experiment. The general principles which Sir W. S. Harris submitted as deducible from the inquiries to which he alluded are these:—If we imagine a ship or building to consist altogether of metallic substances, it would certainly be secure from any damage by lightning and for this simple reason, that what we call lightning is the result of the electrical agency forcing a path through resisting matter such as the air, and extricating, with explosive and expansive force, both light and heat in its course. When, on the contrary, it falls upon comparatively non-resisting bodies, such as the metals, then this form of lightning vanishes, and the discharge assumes, if the metallic body be sufficiently capacious, the form of a comparatively quiescent current. Our object should be, therefore, in defending any building or ship from lightning, to bring the general mass so far as possible into that passive or comparatively non-resisting state it would have supposing it a mass of metal. This is, in fact, the single and simple condition of such an application, without any reference whatever to assumed forces of attraction or peculiar specific powers manifested by certain bodies for the matter of lightning, and which really do not exist. This simple principle, by a careful mechanical arrangement calculated to render it practical and applicable to all the duties which the general structure of a ship together with its masts has to perform, is now universally carried out in the navy, with the most perfect success; so that damage by lightning in the vessels so fitted has, for the last fifteen years, quite ceased. The masts are made completely conducting by capacious plates of copper, reaching from the highest points to the keel; and are tied into one general connexion with all the great metallic masses employed in the construction of the hull, and united by large bolts of copper passing through the keel and sides, with the copper expanded over the bottom and with the sea. It is quite impossible that a discharge of lightning can fall on the vessel in any place, and not be at once transmitted safely by the conductors

without, not under the form of lightning, but under the form of a current explosion. Sir W. S. Harris then referred to some remarkable cases.

5. *On the Colored Glass employed in Glazing the new Palm House in the Royal Botanic Garden at Kew;* by R. Hunt, (Proc. Brit. Assoc., 1847, Athen., No. 1028.)—It has been found that plants growing in stove houses often suffer from the scorching influence of the solar rays, and great expense is frequently incurred in fixing blinds to cut off this destructive calorific influence. From the enormous size of the new Palm House at Kew, it would be almost impracticable to adopt any system of shades which should be effective—this building being 363 feet in length, 100 feet wide and 63 feet high. It was therefore thought desirable to ascertain if it would be possible to cut off these scorching rays by the use of a tinted glass, which should not be objectionable in its appearance, and the question was at the recommendation Sir Wm. Hooker and Dr. Lindley, submitted by the Commissioners of Woods, &c. to Mr. Hunt. The object was, to select a glass which should not permit those heat rays which are the most active in scorching the leaves of plants to permeate it. By a series of experiments made with the colored juices of the palms themselves, it was ascertained that the rays which destroyed their color, belonged to a class situated at the end of the prismatic spectrum which exhibited the utmost calorific power, and just beyond the limits of the visible red ray. A great number of specimens of glass variously manufactured were submitted to examination, and it was at length ascertained that glass tinted green appeared likely to effect the object desired most readily. Some of the green glasses which were examined obstructed nearly all the heat rays—but this was not desired—and from their dark color these were objectionable, as stopping the passage of a considerable quantity of light, which was essential to the healthful growth of the plants. Many specimens were manufactured purposely for the experiments by Messrs. Chance of Birmingham, according to given directions, and it is mainly due to the interest taken by these gentlemen that the desideratum has been arrived at. Every sample of glass was submitted to three distinct sets of experiments—1st. To ascertain, by measuring off the colored rays of the spectrum, its transparency to luminous influence. 2nd. To ascertain the amount of obstruction offered to the passage of the chemical rays. 3rd. To measure the amount of heat radiation which permeated each specimen. The chemical changes were tried upon chlorid of silver, and on papers stained with the green coloring matter of the leaves of the palms themselves. The calorific influence was ascertained by a method employed by Sir John Herschel, in his experiments on solar radiation. Tissue paper stretched on a frame was smoked on one side by holding it over a smoky flame, and then while the spectrum was thrown upon it, the other surface was washed with strong sulphuric ether. By the evaporation of the ether, the points of calorific action were most easily obtained, as these dried off in well defined circles long before the other parts presented any appearance of dryness. By these means it was not difficult, with care, to ascertain exactly the conditions of the glass, as to its transparency to light, heat, and chemical agency, (actinism.) The glass thus chosen is of a very pale yellow-green color, the color being given by oxyd of copper, and is so transparent that

scarcely any light is intercepted. In examining the spectral rays through it, it is found that the yellow is slightly diminished in intensity, and that the extent of the red ray is affected in a small degree, the lower edge of the ordinary red ray being cut off by it. It does not appear to act in any way upon the chemical principle, as spectral impressions obtained upon chlorid of silver are the same in extent and character as those procured by the action of the rays which have passed ordinary white glass. This glass has, however, a very remarkable action upon the non-luminous heat-rays, the least refrangible calorific rays. It prevents the permeation of all that class of heat-rays which exists below and in the point fixed by Sir William Herschel, Sir H. Englefield, and Sir J. Herschel, as the point of maximum calorific action. As it is to this class of rays that the scorching influence is due, there is every reason to conclude that the use of this glass will be effective in protecting the plants, and, at the same time, as it is unobjectionable in point of color, and transparent to that principle which is necessary for the development of those parts of the plant which depend upon external chemical excitation, it is only partially so to the heat-rays, and it is opaque to those only which are the most injurious. The absence of the oxyd of manganese, commonly employed in all sheet glass, is insisted on, it having been found that glass, into the composition of which manganese enters, will, after exposure for some time to intense sunlight, assume a pinky hue, and any tint of this character would completely destroy the peculiar properties for which this glass is chosen. Melloni, in his investigations on radiant heat, discovered that a peculiar green glass, manufactured in Italy, obstructed nearly all the calorific rays; we may, therefore, conclude that the glass chosen is of a similar character to that employed by the Italian philosopher. The tint of color is not very different from that of the old crown glass; and many practical men state that they find their plants flourish much better under this kind of glass than under the white sheet glass, which is now so commonly employed.

6. *On the Application of Gutta Percha for Modeling;* by Mr. Busk, (Proc. Brit. Assoc., Athen., No. 1027.)—After alluding to his experiments, he described the mode he followed in obtaining his moulds:—"It is to be rolled out on a smooth surface in sheets of any convenient size suitable to the object to be taken, and varying in thickness according to the size. For small objects, from the $\frac{1}{12}$ to $\frac{1}{16}$ of an inch is thick enough. The sheet is dipped for a moment or two into *boiling* water, and placed warm upon the object, upon the surface of which it is to be carefully pressed with the finger point, or a convenient elastic pad, so as to insure its close and uniform adaptation. In moulding soft objects it is, of course, necessary that they should possess elasticity or resiliency, as is the case with living or recently dead animal bodies. The gutta percha does not seem to be applicable to taking moulds from very fragile bodies,—such as many fossils, which would not bear the requisite pressure nor admit of the removal of the mould when rigid without risk. The most delicate objects, however, and slender projections, if firm enough in the original, may in the plaster cast be removed from the matrix without any difficulty when the latter is softened by momentary immersion in hot water.

Mr. Jerdan stated that there were two kinds of gutta percha—one white, the other black. The former was the best for modelling. He had written to Mr. Brooke, of Borneo, on the subject, who informed him that an unlimited supply might be obtained from that country.—Mr. Crawfurd said it was not hard till after it was submitted to the heat of boiling water. The proper way of pronouncing the word was gutta pertsha, which was a Malay term, and signified ragged gum.

7. *Report on Atmospheric Waves;* by W. R. Birt, (Proc. Brit. Assoc. for 1847, Athen., No. 1028.)—The author in introducing his fourth Report on this subject observed, that in accordance with the resolution adopted at the last Meeting of the Association, about thirty sets of observations had been obtained from various stations in the British islands; the extremes of the area embraced being the Orkneys and Jersey in one direction, and Galway and Dover in the other. As instances of the increasing interest manifested on this subject, he remarked that he had been furnished with curves from stations in the north, where the barometric movements had been considered to result from the transit of the great November wave. Each of these curves was referred to the same period; namely, from the 2nd to the 17th of November; and the observers invariably regarded the regular rise and fall that occurred between these epochs as indicating a well-marked return of the great symmetrical wave. Mr. Birt, after noticing the remarkable circumstances under which the wave returned last autumn—so remarkable that they had no small tendency to mask the waves in the southeastern part of the island—stated that the projected curve at London strikingly developed its essential features; the *five* subordinate waves were well seen, although the inflexions were not strong, owing to the small altitude of the wave on its last return, scarcely exceeding half an inch—its whole development occurring above thirty inches prevented the boldness of the inflexions particularly noticed on the occasion of its return in 1842. The author then proceeded to notice the essential features of the curves as obtained from observations at Ramsgate, St. Vigean's, near Arbroath, east coast of Scotland, the Orkneys and Western Isles, Applegarth Manse, Dumfries-shire, Largs, Limerick, Galway, Helstone in Cornwall, and St. Helier's Jersey.

Our limits will not permit us to give in detail the resemblances and differences of these curves, exhibiting, as they do, the distribution of pressure around Great Britain and Ireland, which the author traced from the southeastern point towards the northwest: but the report will be printed in the forthcoming volume of the transactions. We may, however, here notice that attention was called to the principle which the author laid down in his report of last year, "that the barometric curve, including a complete rise and fall at any one station, does not represent any reality in nature, but is the effect of two or more systems of waves or currents moving in different directions and crossing each other at various angles." He also pointed out the great extent of oscillation (nearly double) observed in the northwest as compared with the southeasterly observations. The great wave commenced on the 2nd of November; at the northern stations it culminated on the 12th; at the southeastern on the 9th; and it terminated on the 17th. In explaining the differences of epoch as indicating the transit of the crest

being much earlier in the southeast than in the north, Mr. Birt remarked that the observations clearly showed that the barometer passed *two* maxima, one on the 9th, the other on the 12th; and that the whole extent of the British isles might be divided into *two* barometric areas, distinguished in one case by the superiority of the maximum of the 9th, and in the other by the superiority of the maximum of the 12th. A line passing between Arbroath and Newcastle, south of Dumfries, and between Ireland and Wales, separates these areas. Northwest of this line we find the maximum of the 12th superior; southeast of it we find the maximum of the 9th superior. The maximum of the 9th Mr. Birt regarded as the central wave forming the crest of the great wave, and the maximum of the 12th he considered as the crest of the first subordinate wave on the posterior slope.

The author next proceeded to examine the distribution of pressure as manifested by these observations; from which, in connexion with the features of the projected curve, he deduced the following results:—1st. The return of the great symmetrical wave. This occurred in the southeastern angle of our island under very peculiar and remarkable circumstances. The area of greatest symmetry is closely in accordance with the results of former discussions, and goes far to confirm the result deduced from the examination of Sir John Herschel's hourly observations, "that Brussels is entitled to be considered as a point of comparatively gentle barometric disturbance, * * * * and may be regarded as in a certain sense a *nodal* point, where irregularities are smoothed down and oscillatory movement in general is more or less checked, and such movements increase as we recede from Brussels as a centre, especially *towards the northwest.*" The curve of greatest symmetry was obtained from Ramsgate, the nearest station to Brussels. As we proceed *towards the northwest*, the symmetry is considerably departed from, especially by the greater development of the first subordinate wave on the posterior slope, by which the maximum of the 12th became superior. This portion of the wave formed a striking contrast to the similar portion in 1845, which was characterized by a considerable depression.

It is not a little curious, remarked the author, and goes far to show that we are approaching the true explanation of the *nodal* character of Brussels, to observe that movements so dissimilar in their character, so opposite in their value, and presenting themselves under such a diversity of aspects, should, in a certain locality and on particular lines of country, manifest, by means of the barometer, constant and well defined phenomena, that may be recognized year after year, and which give to the curves of barometric rise and fall during the period of their occurrence a peculiar symmetrical appearance. 2nd. Two systems of waves or currents, one having a *general* direction of progress from the northwest, the other from the southwest, traversed the area during the period of the great wave. This is the same result to which we were conducted by an investigation of the symmetrical wave of 1842. The relative positions of the individual waves were somewhat different from those of the wide bi-dual waves of 1842; but there were some striking points of resemblance. The northwesterly system in each case exhibited the largest wave, both as regards amplitude and altitude. The intervals between similar phases of northwesterly waves were nearly

equal in 1842 and 1846. During the interval that elapsed between transits of these similar phases in 1842 and 1846, the same number of southwesterly waves passed overthe area—and from the whole it appears highly probable that we have not only ascertained another return of the great symmetrical wave, (the sixth,) but have also detected the return of at least *three* of the individual waves contributing to its production. 3rd. The very precipitous fall of the barometer characterizing the posterior slopes of the northwesterly systems, as developed by the discussion of the observations of 1842, is fully confirmed: in connexion with this, the decrease of oscillation from the northwest towards the southeast is also strikingly developed, as on former occasions.

The author, in alluding to the area over which these observations extend, remarked that the British Isles present a far too limited area for the purposes of examining thoroughly these atmospheric movements; he observed that in the more extensive examination which the movements of November, 1842, are now undergoing, there are four stations at which the barometric changes are of an opposite character during the first eight days of November,—namely, Christiania and St. Petersburgh in the north, and Paris and Geneva in the south. The curves at St. Petersburgh and Geneva present the most decided opposition; rising at the one while falling at the other. The turning point in each case occurred on the 5th. These opposite movements he conceived to be occasioned by the opposite slopes of two waves passing from the *southwest*, and that the *half* breadth of each wave extended at least from Geneva to St. Petersburgh. Such being the extensive character of the waves in question, in order to judge them in their totality it will be absolutely necessary to enlarge the area of observation. The centre of Europe is well dotted over with barometers, from which accurate results may be obtained; but even the British Isles, in connexion with that portion of Europe now under observation, form but a small part of the vast space over which the waves themselves extend. St. Petersburgh is an important northern station, from which we have most excellent observations; but we require them also from Iceland, the northern parts of Norway, Sweden and Lapland, and also from Archangel in one direction, and from the southern parts of France, from Spain, Portugal and the northern parts of Africa in the other; also from the Mediterranean they would be highly important. Observations stretching from the most western point of Africa to the extreme north of Europe would go far to determine the longitudinal directions of the northwesterly systems of waves. In reporting the general progress of the inquiry, Mr. Birt stated that we are now in possession of the materials for examining the great symmetrical wave, not only in particular years, as 1842, 1845, and 1846, but also over the central parts of Europe and the dominion of the Russian empire, as far as Sitka, on the northwest coast of America. He has combined observations extending from the west coasts of Ireland and the Orkneys on the one hand, to St. Petersburgh and Geneva on the other; and he apprehends that the whole of the barometric movements over this area, which occurred during the first eight days of November, 1842, are fully explained by the transits of two large waves on two sets of parallel beds of oppositely directed

winds—one from the southwest, the other from the northwest. The continuation of the investigation will be submitted at future meetings of the Association.

In connexion with this, the author observed that a most important point appeared to be developing itself by means of these observations. Those from the northwest appeared strongly to indicate that somewhere in that direction the origin of the great barometric disturbances (a centre of oscillation) giving rise to the waves that pass onwards towards the southeast is to be sought. We have already obtained the *nodal* point of the two great systems of European barometric undulations—namely, Brussels. Between the Orkneys, which appear to be the nearest station to the northwest centre of oscillation, and Brussels the greatest decrease of oscillation occurs. This line of the greatest diminution of oscillation appears to be well determined.

The author closed his report with an allusion to the American system of atmospheric waves, especially those that accompanied the great Cuba hurricane of October, 1844, which has formed the subject of an elaborate investigation by Mr. W. C. Redfield, of New York; and was of opinion that the revolving storm, so ably brought to light by Mr. Redfield's labors, was produced by the crossing of two large long waves moving in different directions, as suggested by Sir John Herschel in his "Report on Meteorological Reductions," presented to the Association in 1843.

8. *On the height of Auroral Arches;* by Prof. T. CHEVALLIER, (Proc. Brit. Assoc., 1847, Athen., No. 1029.)—Of all the phenomena of the Aurora Borealis, the arches which are occasionally seen nearly at right angles to the magnetic meridian are the most definite and permanent; and seem to offer the most promising means of ascertaining the height of the region in which that modification of the aurora is formed. In the 118th No. of the "Philosophical Transactions," Dr. Dalton has collected several facts on the subject; and arrives at the conclusion that these arches are about 100 miles high. Having computed the height of three such arches, I am desirous of laying the results briefly before the Association. The first was the aurora of March 22, 1841, observed at Dunse, near Berwick, by Mr. Wm. Stevenson; at Durham, by myself; at Belfast, by Prof. Stevelly; and at York, by Mr. Phillips. The observations over more than an hour, from $8^h\ 56^m$ Greenwich mean time, to $10^h$; and the position of the arch was definitely fixed by its place among the fixed stars. The direction of the arch was magnetically east and west. Its height was computed separately from the observations at York and Durham, York and Belfast, and Belfast and Durham; the resulting altitudes being 156, 157, and 165 miles. The second auroral arch was observed on Sept. 21, 1847, at Esk, near Durham, by myself, and at Norwich by Mr. W. Marshall. It was visible only for about five minutes. The resulting height is 106 miles. This determination depends upon two observations only. The third auroral arch was seen on the 19th of March, 1847. It was observed at Darlington, at Spalding in Lincolnshire, at Cambridge, at Norwich, in London, Oxford and Amsterdam. The observations of Darlington and Cambridge, from a base of 172 miles, give an altitude of 175·9 miles; those of Spalding and Cambridge, from a base of 114 miles, give an altitude of

174·4 miles; and those of Spalding and Darlington, from a base of 58 miles, give an altitude of 174·9 miles;—the mean being 175 miles. The extensive area over which this arch was observed is remarkable. A great magnetic disturbance took place at the same time, extending as far as Toronto. In connexion with the cause of these phenomena, it cannot escape notice that there is great similarity between the two kinds of auroral action and the two modes of magnetic action recently discovered by Prof. Faraday; the ordinary auroral beams being parallel to the direction of the magnetical meridian, and the arches being at right angles to that direction.

9. *On the Resources of Irish Sea Fisheries;* by Mr. R. Valpy, (Proc. Brit. Assoc., 1847, Athen. No. 1027.)—Having dwelt at some length on the great abundance of fish in the Irish seas and the want of food by the Irish people, he stated that so far back as the ninth and tenth centuries the Danes had fisheries on the western coast of Ireland, from whence they sent large exports to the south of Europe. In Queen Mary's reign, Phillip II. paid 1,000*l.* annually to purchase for the Spaniards a right of fishing on the Irish coast. The Dutch purchased a similar right from Charles II. for 30,000*l.*; and in 1650, Sweden was permitted, as a favor, to employ 100 vessels in the Irish fishing. From 1800 to 1830 the immense sum of 276,784*l.* was paid in bounties for the encouragement of Irish fisheries; but the system was found to encourage fraud rather than stimulate industry, and it was abolished. In 1821, the number of boats employed in the Irish fisheries were:—

| | First class. | Second class. | | Men |
|---|---|---|---|---|
| | 2,766 | 4,889 | worked by | 36,159 |
| In 1829 (the year before the abolition of the bounty) the numbers were | 3,599 | 9,552 | " | 64,771 |
| In 1836, " " | 2,897 | 7,864 | " | 54,119 |
| In 1843, " " | 2,371 | 17,512 | " | 93,073* |

Thus the abolition of the bounty, though it threw back the fisheries for a time, did not eventually injure their progress; the increase between the years 1836 and 1843 amounting to 37 per cent. All the inspectors of fisheries agree that within the last few years the character of the persons employed in the fisheries has been greatly improved. The author related minutely the history of several abortive efforts to establish joint-stock companies for conducting the fisheries of Ireland; one of which, that of Dunmow, near Waterford, seemed an one time to have very fair prospects of success. Having dwelt at some length on the white fishery, cod, ling, &c.—but with rather vague data for an estimate of its results—the notorious frauds committed under the bounty system rendering the returns then made to Government utterly unworthy of confidence—Mr. Valpy directed attention to the herring fishery. The Irish herrings are better in quality and bring higher prices than those of Scotland, but they are for the most part fished on the coast, the fishermen being prevented from going in search of the

* The numbers for 1846 are, boats of the first class 2,424, second class 11,793, men 98,538.

shoals by want of suitable boats and tackle. The coast fishery is very uncertain because the herring shoals do not always take the same course, and the fish caught in the deep sea are more abundant and better in quality than those taken near the shore. The Swedes and Dutch pursue the deep-sea fishery with great advantage. The salmon-fisheries of Ireland were then examined. The chief statistics on the subject were obtained from the extensive and well known firm of Messrs. Keays & Co.; but, as the trade is subject to the most capricious fluctuations, we do not think that any safe deductions could be made from the returns of a single house. There is no doubt that the import of Irish salmon into England has increased and is increasing. Irish turbot, soles, and lobsters might profitably be brought to the same market. A desultory discussion took place, in which several explanations of the neglect of the Irish fisheries were suggested. Ignorance, obstinate prejudices, strange superstitions, want of government encouragement, want of capital, acts of violence by which capitalists are deterred from investing their money, the perilous condition of the Irish coasts, particularly in the west, uncertainty of supply, and distance of market.

10. *Smithsonian Institution*, (from the Literary World, Sept. 18, 1847.)—We are glad to have it in our power to announce the first publication of the Smithsonian Institution.

It will be remembered that Mr. Smithson directed, in his will, that his bequest should be devoted to the *increase* and *dissemination* of knowledge. It is therefore incumbent on the Regents of the Institution, endowed by the liberality of Mr. Smithson, to publish and disseminate useful knowledge, and particularly such as may be an addition to our present stock, or the result of original research. The first work to be issued is one strictly in accordance with the wishes of the testator: inasmuch as it will impart facts relating to the early people of the American continent, which are as new as they are interesting. We consider it a fortunate event, therefore, that the Regents of the Smithsonian Institution have secured the work in question, as none could be more appropriate. It will, without doubt, be well received, and hailed as a good beginning by the numerous readers into whose hands the volume may fall.

This work, containing researches into the origin and purposes of the aboriginal monuments and remains of the Mississippi Valley, will embrace the details and results of extended surveys carried on during several years by Mr. E. G. Squier and Dr. E. H. Davis, of Ohio. The labors of these gentlemen embrace the opening and examination of more than two hundred mounds, of every variety and character, from the greatest to the least. These works were not carelessly overthrown, but laid open to their centre; the relics, if any existed, were removed, and the earth again replaced. In these examinations, the number and variety of aboriginal relics which have been brought to light, must excite astonishment in all. Their collection embraces many thousand objects, exhibiting the state of the arts among the ancient people, of whose existence they are the only memorials. They consist of implements and ornaments in silver, copper, lead, stone, ivory and pottery, fashioned into a variety of forms, and exhibiting a skill which, in some instances, modern art cannot surpass. The sculptures of birds, animals and rep-

tiles, constitute a large class of these ancient relics. They are cut from various kinds of stone, and in many instances from porphyry. Several highly finished sculptures of the human head are deserving of notice, and probably convey an idea of the physical character of the people. A single skull, the only one out of many hundreds discovered in fragments, which has been preserved entire, and which our explorers are satisfied belongs to the primitive people, is all we have, aside from these, to enable us to form an opinion of the race.

In examining the remains, we discover articles which show the extent of their intercourse with other parts of the country. Thus, there are instruments of *obsidian*, a volcanic substance found only in Mexico —native copper and lead from Lake Superior and the Upper Mississippi—marine shells and cetacean teeth from the sea, and numbers of pearls of great beauty.

But the mounds and their contents are but a small portion of interesting facts made known by these gentlemen, for we consider the vast earth-works the most remarkable. Their labors embrace surveys of more than one hundred works of this description, some of them miles in extent. Others are vast enclosures covering a space equal to that occupied by the city of New York. Again, we see fortified places, in the construction of which modern military science might perhaps derive some useful hints.

The work in question will embrace the details of these most curious and interesting explorations, and will be illustrated with several hundred wood engravings in the highest style of the art. These will exhibit representations of the relics discovered—views of the mounds and other ancient remains—sections, plans, &c. It will also contain seventy quarto lithographic plans, being the surveys of the other works alluded to, laid down on an accurate scale. What will be the extent of the letter-press we are unable to say, but it will probably exceed 500 quarto pages.

Such is a very brief account of the discoveries which this work will make known. The facts deduced from them open a new era in our aboriginal history. The question will naturally arise, at what period, and by whom, were these works erected? What has become of the people? Had they any connexion with the nations of the other hemisphere? &c. &c.

The relics and the works themselves aid but little in determining the period when they were made. When the country was settled, they were covered with large trees, exhibiting as great an age as the forest around them. But there are other facts connected with their position, which show that great physical changes have taken place since their creation. These aid us in determining their antiquity, which must be reckoned by thousands of years rather than by centuries.

Many analogies are presented to our explorers, in investigating the antiquities and primitive history of some of the earlier nations of the Old World. The serpent and egg, which has a prominent place in the mythology of Egypt and India, typifying a universal principle, has actually been found in Ohio, in a well defined serpent 1200 feet in length, formed of earth, in the act of swallowing an egg. Some striking analogies with the Druidical rites, are also discovered. The Phallic wor-

ship, too, so universal throughout the ancient world, may be traced in the remains of the Mississippi valley, as well as many coincidences, as interesting as they are remarkable. Dissertations on these will accompany the work. We cannot close our remarks without speaking of the gentlemen who are engaged in the work. Dr. Davis has, for fifteen years, been a resident of Chillicothe, during which time he has been a close observer, and has collected many valuable relics from the mounds. Mr. Squier removed to the same place a few years since, when a more thorough system of survey and examination of the earth-works was commenced. A number of laborers were employed, and when the weather permitted, these gentlemen were in the field with their spades, surveying instruments, and sketch-book. For three years they have been incessantly engaged in their work. From a personal acquaintance with Mr. Squier, we do not hesitate to say that the exploration and survey of our ancient remains could not have fallen into better hands. Combined with a perseverance in the undertaking, and enthusiasm for the subject, he is an accomplished draughtsman and surveyor; an evidence of which may be seen in the splendid and numerous surveys and drawings with which his portfolios are filled.

11. *Prospectus of the Publication of a New Series of the Journal of the Academy of Natural Sciences of Philadelphia*, (issued by the Acad.)—The publication of this Journal having been unfavorably suspended for several years, it is now proposed to resume it in a New Series, to commence about the middle of the present year.

The first part containing about eighty pages in *quarto form*, will be issued in September, and the work will be continued thereafter semi-annually, so that two parts will appear each year, or four in two years, which will form a volume.

The work will be printed on fine paper, with ample lithographic and other illustrations, at $5 per volume, or $1 25 for each part.

The printed Proceedings of the Society will be distributed to subscribers to the Journal free of charge, during the period of their subscription.

12. *On the Discovery of Gun-Cotton;* by Professor Schœnbein, (Archives des Sciences Physiques et Naturelles; L., E. and D. Phil. Mag., vol. xxxi, p. 7.)—The substance to which I have given in German the name of *schiesswolle*, and in English that of gun-cotton, having excited a lively curiosity, it may be interesting to the scientific world to become acquainted with some details of the way in which I was first led to its discovery.

The results of my researches on ozone led me in the course of the last two years to turn my attention particularly to the oxyds of nitrogen, and principally to nitric acid. The numerous experiments I have made on this subject have led me, as I have stated in detail in Poggendorff's *Annalen*, to adopt a peculiar hypothesis on the so-called hydrates of nitric acid, sulphuric acid, &c., as well as on the normal nitrates, sulphates, &c.

For a long time I had entertained doubts as to the existence of compound bodies of this nature, which cannot be isolated, and which are stated to be capable of existing only in combination with certain other substances; for a long time also I had come to the notion that the in-

troduction of these imaginary combinations had only been an apparent progress in theoretical chemistry, and that it had even impeded its development.

It is well known that what has most contributed to the admission of the existence of these compounds, has been the opinion generally received among chemists respecting the nature of nitric acid. Starting from the existence of the compound of nitrogen $NO_5$, as an undoubted and demonstrated fact, notwithstanding the impossibility of isolating it, they always cite nitric acid to prove the existence of compounds which cannot exist in an isolated state. In my opinion, there is no degree of oxydation which is represented by $NO_5$, and what these chemists designate by the formula $NO_5+HO$ must be considered as being really $NO_4+HO_2$; I am even inclined to regard the normal nitrates $NO_5+RO$, as compounds which must be expressed by $NO_4+RO_2$. Amongst other motives which induce me to admit this opinion, I will mention the fact that we can obtain hydrated nitric acid or a normal nitrate by the direct mixture of $NO_4$ with $HO_2$ or $RO_2$. Other considerations, which I have had occasion to detail elsewhere, induce me also to consider hydrated sulphuric acid to have the form $SO_2+HO_2$, and not that of $SO_3+HO$, and a normal sulphate that of $SO_2+RO_2$. It is sufficient here to observe that $SO_2$ placed in presence of $HO_2$ gives rise to what is called hydrated sulphuric acid, and that $SO_2$ placed in presence of $BaO_2$ or $PbO_2$ gives rise to what is called sulphate of the oxyd of barium or of lead. Rose's compound, to which the formula $2SO_3+NO_2$ has been assigned, should have, in my opinion, $2SO_2+NO_4$. Admitting this, I considered it probable that the mixture of $2(SO_2+HO_2)$ $(=2(SO_3+HO))$ with $NO_4+HO_2$ $(=NO_5+HO)$ yields $2SO_2+NO_4$, and that at the same time $3HO_2$ is disengaged, or enters into a loose combination with what is called the bisulphate of deutoxyd of nitrogen. In other words, I conjectured that a mixture formed with the hydrates of nitric acid and sulphuric acid would possess a very great power of oxydation, and would form a kind of *aqua regia*, in which the combination $HO_2$ would act the part of the chlorine. On this hypothesis, and abstracting $HO_2$ from the acid mixture by means of a proper oxydable body, there ought to remain Rose's compound.

Guided by these suppositions, which, I admit, may be as little founded as they are contrary to the ideas received among chemists, I commenced in December, 1845, a series of experiments with a view to put my hypothesis to the proof: it will be seen in the sequel whether the results at which I arrived tend to confirm it.

I mixed some flowers of sulphur and a certain quantity of the acid mixture of which I have spoken: immediately, even at a temperature of 32° F., a lively disengagement of sulphurous acid gas took place without the production of deutoxyd of nitrogen. After the reaction, which was accompanied by a development of heat, there remained a colorless liquid, which, mixed with water, disengaged a considerable quantity of deutoxyd of nitrogen, and acted generally as a solution of Rose's compound in hydrated sulphuric acid would have done.

I should add here, that a mixture of four ounces of hydrated sulphuric acid with a single drop of nitric acid, on the addition of flowers of

sulphur, disengages a sensible quantity of sulphurous acid. To assure himself of the presence of the latter, the operator has only to hold over the liquid a strip of paper which has been covered with iodid of potassium paste, and tinged slightly blue by exposure to chlorine. The liberated sulphurous acid will soon dissipate this blue color.

Selenium and phosphorus are oxydized in the same manner at low temperatures in the acid mixture in question; and this latter is modified to such an extent, that, on the addition of water, an abundant disengagement of deutoxyd of nitrogen gas takes place.

Iodine even, in the state of powder and shaken up with the acid mixture, rapidly absorbs oxygen, when exposed to a low temperature; and there is formed, besides iodic acid, the compounds to which Millon has lately drawn attention. After the reaction, a liquid remains, which, diluted with water, gives an abundant disengagement of deutoxyd of nitrogen and liberates iodine.

My experiments on ozone having shown that this body, which I consider to be a distinct peroxyd of hydrogen, forms, as well as chlorine, at the ordinary temperature, a peculiar compound with olefiant gas, without apparently oxydizing in the least either the hydrogen or the carbon of this gas, I had the idea that it would not be impossible that certain organic matters, exposed to a low temperature, would likewise form compounds, either with the peroxyd of hydrogen alone, which, on my hypothesis, occurs in a state of combination or of mixture in the acid mixture, or with $NO_4$. It was this conjecture, doubtless very singular in the eyes of chemists, which principally led me to commence experiments with common sugar.

I made a mixture of one part (volume) of nitric acid, of 1·5 spec. grav., and two parts of sulphuric acid of 1·85, at the temperature of 36° F.; I then added some finely powdered sugar, so as to form a very fluid paste. I stirred the whole, and, at the end of a few minutes, the saccharine substance formed itself into a viscous mass entirely separated from the acid liquid, without any disengagement of gas. This pasty mass was washed with boiling water, until this last no longer exercised any acid reaction; after which I deprived it, as much as possible, at a low temperature, of the water it still contained. The substance now possessed the following properties:—Exposed to a low temperature, it is compact and brittle; at a moderate temperature, it may be moulded like jalap resin, which gives it a beautiful silky lustre. It is semi-fluid at the temperature of boiling water; at a higher temperature, it gives off red vapors; heated still more, it suddenly deflagrates with violence, without leaving any perceptible residue. It is almost insipid and colorless, transparent like the resins, almost insoluble in water, but easily soluble in the essential oils, in ether and concentrated nitric acid, and in most cases it acts in general like the resins in a chemical and physical point of view: thus friction renders it very electro-negative. I will add, that the acid mixture, by means of which this resinous body was obtained, has an extremely marked bitter taste.

I wished to make experiments also with other organic substances; and I soon discovered, one after another, all those about which there has been so much said of late, especially in the Academy of Paris. All this passed in December, 1845, and the first few months in 1846.

In March, I sent specimens of my new compounds to some of my friends, in particular to Messrs. Faraday, Herschel and Grove. It is necessary to note expressly that the gun-cotton formed part of these products; but I must add, that hardly was it discovered when I employed it in experiments of shooting, the success of which encouraged me to continue them. Accepting the obliging invitation which I received, I went in the middle of April to Wurtemburg, and made experiments with gun-cotton both in the arsenal of Ludwigsburg, in the presence of artillery officers, and in Stuttgard, before the king himself. In the course of May, June and July, with the kind coöperation of the Commandant de Mechel, of M. Burkhardt, captain of artillery, and other officers, I subsequently made in this city (Bâle) numerous experiments with arms of small calibre, such as pistols, carbines, &c., and afterwards with mortars and cannon,—experiments at which Baron de Krüdener, the Russian ambassador, was several times present. I may be allowed to mention, that I was the person who fired the first cannon loaded with gun-cotton and shot, on the 28th of July, if I remember aright, after we had previously ascertained, by experiments with mortars, that the substance in question was capable of being used with pieces of large calibre.

About the same time, and indeed previously, I employed gun-cotton to blast some rocks at Istein in the Grand Duchy of Baden, and to blow up some old walls at Bâle; and in both cases I had opportunities of convincing myself in the most satisfactory manner, of the superiority of this new explosive substance over common gunpowder.*

Experiments of this kind, which took place frequently and in the presence of a great number of persons, could not long remain unknown; and the public journals soon gave, without participation on my part, descriptions, more or less accurate, of the results which I had obtained. This circumstance, joined to the short notice which I inserted in the May number of Poggendorff's *Annalen*, could not fail to attract the attention of German chemists: in the middle of August I received from M. Bœttger, Professor at Frankfort, the news that he had succeeded in preparing gun-cotton and other substances. Our two names thus became associated in the discovery of the substance in question. To M. Bœttger the gun-cotton must have been particularly interesting, as he had previously discovered an organic acid which deflagrates readily.

In the month of August I went to England, where, assisted by the able engineer, Mr. Richard Taylor of Falmouth, I made numerous experiments in the mines of Cornwall, which were entirely successful, in the opinion of all competent witnesses. Experiments on the action of gun-cotton were also made in several parts of England, under my direction, both with small firearms and with pieces of artillery, and the results obtained were very satisfactory.

Until that time there had been little or nothing said of gun-cotton in France; and it will appear that the short notices which Mr. Grove gave at Southampton at the meeting of the British Association, and the experiments with which he accompanied them, served first to attract the

* In the month of June I made also the first percussion caps, and employed them with success for muskets, in the presence of the above-named officers.

attention of French chemists to this substance. At Paris, the thing was at first considered hardly credible, and jokes even were passed upon it; but when there could no longer remain any doubt as to the reality of the discovery, and when several chemists in Germany and other countries had published the processes which they employed to prepare the gun-cotton, then a lively interest was manifested in a subject which had just before excited derision, and it was soon pretended that the new explosive substance was an old French discovery. It was declared to be nothing more than the xyloïdine first discovered by M. Braconnot, and afterwards investigated anew by M. Pelouze, and the only merit left me was to have conceived the happy idea of putting this substance into a gun-barrel. The knowledge of the composition of xyloïdine ought to have sufficed to convince those who put forward that opinion, that it is not suited for firearms, on account of its containing too much carbon and too little oxygen for the chief part to be converted into gaseous matters during the combustion. It was moreover very easy to discover the essential differences which exist between the xyloïdine of Braconnot and gun-cotton. Nevertheless the error was kept up for some months.

Matters stood thus, when, on the 4th of last November, a Scotch chemist, Mr. Walter Crum of Glasgow, published a memoir, in which he showed that gun-cotton is not the same product as xyloïdine, but that it presents an essentially different composition; and towards the end of the same month, the French Academy received a communication of the same nature. The gun-cotton was then no longer xyloïdine; it was called pyroxyloïdine, and the first was admitted to be unsuitable for firearms.

If, therefore, it is proved that from the commencement of 1846 I prepared gun-cotton, and applied it to the discharge of fire-arms and that M. Bœttger did the same in the month of August,—if it be admitted that xyloïdine cannot serve the same purposes as this cotton, and if it be notoriously known that what is now called pyroxyloïdine was not brought before the French Academy and the scientific world until towards the middle of last November, the idea of attributing to France the discovery of gun-cotton cannot be seriously entertained, or of assigning to me merely a practical application of that which another would have discovered.

I appeal to the justice of Frenchmen, to decide the point to whom belongs the honor of not only being the first to apply the new substance in question, but also of having first prepared it—to MM. Braconnot and Pelouze, or myself. I must, moreover, add expressly, that it was not xyloïdine even which led to my discovery, however intimate may be its relation with gun-cotton; it was theoretical ideas, possibly very erroneous ones, but which are peculiarly my own, as well as some facts which I was also the first to discover. *Suum cuique* is a principle of morality on which society at large rests; why should it not be strictly respected in the republic of science? M. Pelouze is a distinguished chemist, and already possesses a sufficiently high reputation not to require to elevate his pretensions on the merits of others; and I am fully persuaded that this estimable chemist, of well known truth of character, will, appreciating with impartiality the circumstances which have occurred, freely render me the justice to which I consider myself entitled.

Bâle, Dec. 28, 1846.

13. *Microscopic Examination of Gun-Cotton;* by Dr. BACON, (Proc. Boston Soc. Nat. Hist., Feb., 1847, p. 195.)—Specimens of the cotton, before and after preparation, were put up in Canada balsam on slips of glass, and covered by very thin glass. When viewed by transmitted light, with powers from 150 to 800, many of the fibres of the gun-cotton appear thickened, but no other change can be perceived on comparison with the unprepared article. There is no appreciable difference in the transparency of the two.

They were now examined in polarized light by means of the polarizing attachment to the microscope. When the polarizing and analyzing prisms are so arranged as to afford a dark field, the riband-like fibres of the cotton before preparation are seen as luminous objects upon a black ground, and are tinged with bright and varied colors. They are thus proved to possess a strong polarizing power. The gun-cotton, under the same circumstances, presents an entirely different appearance. Its fibres are much less luminous, and have a nearly uniform dull blue color. It is evident that the process of preparation has so altered the structure of the fibres as to lessen very greatly their action on polarized light.

Gun-cotton prepared by Dr. Jackson by immersion for twelve and for eighteen hours in the strongest acids, has not lost its polarizing power in any appreciably greater degree than after an immersion of three minutes only. This agrees with the results of other modes of trial in indicating that the latter period is sufficient for the complete preparation of the cotton, when the acids are of full strength. In all the specimens there are some filaments so nearly destitute of polarizing power as to be scarcely visible on the black ground, but none have been found entirely without action. When the polarizing and analyzing prisms are in such a position as to give a bright field, a portion of the fibres becomes tinged with a color approaching to orange, while the remainder appear colorless as in ordinary light.

14. *On the Production of Vanilla in Europe*, (Gardner's Travels in the interior of Brazil, p. 296; Jameson's Jour., xlii, 382.)—In marshy bushy places on this journey, I saw many plants of the *Vanilla planifolia*, seldom bearing flowers, and more rarely producing fruit. It has now been satisfactorily determined, that this is the species from which the true vanilla of commerce is procured. In Mexico it is extensively cultivated for the sake of its fruit, which it yields abundantly: while the plants which have been introduced into the East Indies, and the hothouses of Europe, though they have frequently produced flowers, have very seldom perfected their fruit. Dr. Morren of Liége was the first to study attentively the natural history of this plant, and to prove experimentally that the fruit of the vanilla may be as freely produced in our hothouses as it is in Mexico. He has discovered that from some peculiarities in the reproductive organs of this plant, artificial fecundation is required. In the year 1836, a plant in one of the hothouses in the botanic garden at Liége produced fifty-four flowers, which having been artificially fecundated, exhibited the same number of pods, quite equal to those imported from Mexico; and, in 1837, a fresh crop of about a hundred pods was obtained upon another plant by the same method. He attributes the fecundation of the plant in

Mexico to the action of some insect which frequents the flower; and hence accounts for the non-production of fruit in those plants which have been removed to other countries, There can be no doubt that this plant is as perfectly indigenous to Brazil as it is to Mexico: but it is no less certain that its fruit is there seldom matured. Is this also to be attributed to the absence of the means by which nature is supposed to effect fecundation in Mexico? This is a subject which, as Professor Morren justly observes, well deserves attention in a commercial point of view, since his experiments go to prove that in all intertropical countries vanilla might be cultivated, and a great abundance of fruit obtained.

15. *Phosphorescent Fungus*, (Gardner's Travels in the interior of Brazil, p. 346; Jameson's Jour., xlii, p. 382.)—One dark night, about the beginning of December, while passing along the streets of the Villa de Natividade, I observed some boys amusing themselves with some luminous object, which I at first supposed to be a kind of large fire-fly; but on making enquiry, I found it to be a beautiful phosphorescent fungus, belonging to the genus *Agaricus*, and was told that it grew abundantly in the neighborhood, on the decayed leaves of a dwarf palm. Next day I obtained a great many specimens, and found them to vary from 1 to 2½ inches across. The whole plant gives out at night a bright phosphorescent light, of a pale greenish hue, similar to that emitted by the larger fire-flies, or by those curious soft-bodied marine animals, the *Pyrosoma*. From this circumstance, and from growing on a palm, it is called by the inhabitants "Flor de Coco." The light given out by a few of these fungi, in a dark room, was sufficient to read by. It proved to be quite a new species; and since my return from Brazil, has been described by the Rev. Mr. Berkeley, under the name of *Agaricus Gardneri*, from preserved specimens which I have brought home. I had already named it *A. phosphorescens*, not being aware at the time I discovered it that any other species of the same genus exhibited a similar phenomenon: such, however, is the case in the *Agaricus olearius* of De Candolle; and Mr. Drummond, of the Swan River Colony, in Australia, has given an account of a very large phosphorescent species, occasionally found there.

16. *Effects of Datura sanguinea, R. Pav*, (Travels in Peru, by Dr. J. J. Von Tschudi, p. 269; Jameson's Jour., xlii, 384.)—To this plant the natives give the names *Huacacachu*, *Yerba de Huaca*, or *Bobachevo;* and they prepare from its fruit a very powerful narcotic drink, called *tonga*. The Indians believe that by drinking the tonga they are brought into communication with the spirits of their forefathers. I once had an opportunity of observing an Indian under the influence of this drink. Shortly after having swallowed the beverage he fell into a heavy stupor; he sat with his eyes vacantly fixed on the ground, his mouth convulsively closed, and his nostrils dilated. In the course of about a quarter of an hour his eyes began to roll, foam issued from his half-opened lips, and his whole body was agitated by frightful convulsions. These violent symptoms having subsided, a profound sleep of several hours succeeded. In the evening I again saw this Indian. He was relating to a circle of attentive listeners the particulars of his vision, during which he alleged he had held communication with the spirits of his forefathers. He appeared very weak and exhausted.

In former times the Indian sorcerers, when they pretended to transport themselves into the presence of their deities, drank the juice of the thorn-apple, in order to work themselves into a state of ecstacy. Though the establishment of Christianity has weaned the Indians from their idolatry, yet it has not banished their old superstitions. They still believe that they can hold communication with the spirits of their ancestors, and that they can obtain from them a clue to the treasures concealed in the *huacas*, or graves; hence the Indian name of the thorn-apple—*Huacacachu*, or grave-plant.

17. *The Condor of the Cordillera*, (Travels in Peru, by J. J. Von Tschudi, p. 300; Jameson's Jour., xlii, 387.)—In these sterile heights nature withholds her fostering influence alike from vegetable and animal life. The scantiest vegetation can scarcely draw nutriment from the ungenial soil, and animals shun the dreary and shelterless wilds. The condor alone finds itself in its native element amidst these mountainous deserts. On the inaccessible summits of the Cordillera that bird builds its nest, and hatches its young in the months of April and May. Few animals have attained so universal a celebrity as the condor. That bird was known in Europe at a period when his native land was numbered among those fabulous regions which are regarded as the scenes of imaginary wonders. The most extravagant accounts of the condor were written and read, and general credence was granted to every story which travellers brought from the fairy land of gold and silver. It was only at the commencement of the present century that Humboldt overthrew the extravagant notions that previously prevailed respecting the size, strength, and habits of that extraordinary bird.

The full-grown condor measures, from the point of the beak to the end of the tail, from four feet ten inches to five feet; and from the tip of one wing to the other, from twelve to thirteen feet. This bird feeds chiefly on carrion; it is only when impelled by hunger that he seizes living animals, and even then only the small and defenseless, such as the young of sheep, vicuñas, and llamas. He cannot raise great weights with his feet, which, however, he uses to aid the power of his beak. The principal strength of the condor lies in his neck and in his feet; yet he cannot, when flying, carry a weight exceeding eight or ten pounds. All accounts of sheep and calves being carried off by condors are mere exaggerations. This bird passes great part of the day in sleep, and hovers in quest of prey chiefly in the morning and evening. Whilst soaring at a height beyond the reach of human eyes, the sharp-sighted condor discerns his prey on the level heights beneath him, and darts down upon it with the swiftness of lightning. When a bait is laid it is curious to observe the numbers of condors which assemble in a quarter of an hour, in a spot near which not one had been previously visible. These birds possess the senses of sight and smell in a singularly powerful degree.

Some old travellers, Ulloa among others, have affirmed that the plumage of the condor is invulnerable to a musket ball. This absurdity is scarcely worthy of contradiction; but it is nevertheless true that the bird has a singular tenacity of life, and that it is seldom killed by firearms, unless when shot in some vital part. Its plumage, particularly on the wings, is very strong and thick. The natives, therefore, seldom

attempt to shoot the condor; they usually catch him by traps or by the lasso, or kill him by stones flung from slings, or by the *Bolas*. A curious method of capturing the condor alive is practiced in the province of Abancay. A fresh cow-hide, with some fragments of flesh adhering to it, is spread out on one of the level heights, and an Indian provided with ropes creeps beneath it, whilst some others station themselves in ambush near the spot ready to assist him. Presently a condor, attracted by the smell of the flesh, darts down upon the cow-hide, and then the Indian, who is concealed under it, seizes the bird by the legs, and binds them fast in the skin, as if in a bag. The captured condor flaps his wings, and makes ineffectual attempts to fly; but he is speedily secured, and carried in triumph to the nearest village.

The Indians quote numerous instances of young children having been attacked by condors. That these birds are sometimes extremely fierce is very certain. The following occurrence came within my own knowledge whilst I was in Lima. I had a condor, which, when he first came into my possession, was very young. To prevent his escape, as soon as he was able to fly, he was fastened by the leg to a chain, to which was attached a piece of iron, of about six pounds weight. He had a large court to range in, and he dragged the piece of iron about after him all day. When he was a year and a half old he flew away, with the chain and iron attached to his leg, and perched on the spire of Santo Tomas, whence he was scared away by the carrion hawks. On alighting in the street, a negro attempted to catch him for the purpose of bringing him home; upon which he seized the poor creature by the ear, and tore it completely off. He then attacked a child in the street (a negro boy of three years old), threw him on the ground, and knocked him on the head so severely with his beak, that the child died in consequence of the injuries. I hoped to have brought this bird alive to Europe; but after being at sea two months on our homeward voyage, he died on board the ship in the latitude of Monte Video.

18. *Fossil Footprints;* by JAMES DEANE, (from a letter to Prof. Silliman.)—I beg your permission to correct an error which occurred in the March number of your Journal, relative to a communication of mine in a preceding number.

It is there stated, page 276, that "you are informed by Prest. E. Hitchcock, that the quadruped tracks figured by me, p. 79 of this volume, and supposed to be new, are the *Sauroidichnites palmatus* of his Geological Report, or the *Palamopus anomalus* of his new nomenclature, &c. He lately examined the original specimen in the collection of Mr. Marsh, and immediately recognized it as belonging to the species just mentioned."

I saw this statement with surprise and immediately referred to the descriptions of Prest. H., which are as follows.

"*S. palmatus.* Toes 4, all directed forward: the three outer ones resemble very much the three front toes of most of the species already described; the middle one being somewhat, but not very much, the longest; and those on each side nearly equal. The inner or fourth toe is very short. Length of foot 2½ to 3 inches. Shown of the natural size and in relief on Pl. 34, fig. 15, &c."

"It will be seen from the drawing that the animal which made the tracks was a biped. For the short or fourth toe is found upon opposite sides of the foot in the different tracks, which would not be the case if it were made by the hind and forefoot of a quadruped; and the fact that both tracks point in, almost exactly in the same direction, is with difficulty reconciled to the idea that they were made by the hind and fore feet of a quadruped on different sides of the body, &c."

These arguments appear to be very conclusive in proof of the *biped* character of the impressions, which sustain no analogy to mine. Instead of a single, they were arranged in double rows; instead of pointing "directly forward," the divergence of the feet was remarkable; and instead of being 2½ or 3 inches in length, they were not half so large. My belief is, that there were five instead of four toes. In fact, there is no analogy, however faint.

Greenfield, July 15, 1847.

19. *The Geological Society of France* held its extraordinary session this year at Epinal (Vosges), on the 10th of September. The Society was guided in this selection by the facility of examining in this region a great variety of deposits of geological interest; to wit, the grès de Vosges, which surrounds Epinal on all sides; to the southeast, granitic rocks, gneiss, leptynite, serpentine and porphyry; and to the northwest, the plains of Lorraine, the grès bigarré, muschelkalk, lias and oolite. The basalt of the coast of Essey, the thermal sources of Plombières and the baths of Luxeuil, were also objects of interest. The region is besides interesting for its phenomena of erratic blocks, and the terraces of the valley of the Moselle.

20. *American Science in Turkey.*—We ought long since to have mentioned that our excellent chemical correspondent, Dr. J. Lawrence Smith, of Charleston, S. C., had gone to Constantinople, in the employ of the Sultan as chemist and geologist. He has been successful in discovering valuable deposits of coal and other useful minerals in the Turkish possessions, some account of which we hope to receive from Dr. S. He has also exhibited the electric telegraph in the Royal palace, and his Highness the Sultan was pleased to express himself highly delighted with its performances, and a rumor has reached this country that a decoration of diamonds and a complimentary diploma had been ordered to be sent as a mark of the royal esteem, to Prof. Morse.

There are at the present time several scientific men of different nations in the employ of the Sultan in various scientific pursuits.

21. *Prof. Agassiz.*—We are credibly informed that this distinguished naturalist has consented to accept an invitation to remain in this country in connection with the scientific corps of Harvard College. Every scientific man in America will be rejoiced to hear so unexpected a piece of good news.

22. *Large Crystal of Columbite.*—The large crystal of columbite described in vol. xxx, at p. 387 of this Journal, has been recently purchased for the Wesleyan University in Middletown, Conn.; its weight is 6 pounds 12 oz., and the mass of which it is a portion, weighed 14 pounds.

## VI. Bibliography.

1. *The London Geological Journal and Record of Discoveries in British and Foreign Palæontology.*—No. 1 of this Journal appeared in September, 1846—one year ago: No. 2 was published in February and No. 3 in May, 1847; it was announced for six Nos. in a year, but has encountered some of the delays incident to new periodical works. The three numbers include 132 pages of letter-press. The editor, Mr. Ed. Charlesworth, F.G.S., &c., long known as a distinguished naturalist, avowedly avoids long memoirs and discussions, and prefers a terse originality, including criticisms upon the works of other naturalists. The work is got up in a beautiful style of paper and print, and the plates are of unrivalled finish and elegance. There are 23 plates in these three Nos., and several of them of large size. Hitherto the articles are chiefly palæontological and possess a high degree of interest. They are as follows—

No. I.—1. An Alligator and several new mammalia in Hordwell Cliff. Searles Wood, F.G.S.

2. Ichthyosaurus—a new species in Chalk. James Carter, M.R.C.S.

3. Chiton in Magnesian Limestone. Wm. King.

4. Prices of some Fossils. G. A. Mantell, LL.D., F.R.S.

5. Coprolites? in the Crag and London Clay. John Brown, F.G.S.

6. A Reptile or Fish in the chalk of Kent. Toulmin Smith.

7. Mosasaurus with flint in the teeth. Ed. Charlesworth, F.G.S.

8. *Miscellanies*—Exposition of the plan of the Geological Journal. Ear bones of Whales in the Red Crag. Fossil reindeer. British Fauna. New genus of Mammals, South Carolina. Fossil foraminifera, —soft parts in Chalk and Flint. Fossil mammalia and aves in Museum of Royal College of Surgeons.

*Obituary*—Miss Ethelred Bennett. Literary Intelligence.

No. II.—1. Large species of Unio in the Wealden of Isle of Wight. G. A. Mantell.

2. Tellina, Monograph of, in the Eocene, &c. Fr. Edwards.

3. Brachiopoda of Wenlock Limestone. Th. Davidson, M.G.S., of France.

4. Belemnite in Oxford clay. R. Owen, F.R.S. Extracts.

5. Fossil Cephalopoda, genus Belemnoteuthis. J. C. Pearce, F.G.S.

*Miscellanies*—Criticism by the Editor. Bibliographical Notices. Extinct Irish Deer. Labors of Agassiz on the Ganoidei. Astacus Phillipsii. Azoic sedimentary strata. Fossil Xanthidea. Pentacrinus, new species. Freshwater strata of Hordwell.

No. III.—1. Fossil Cephalopoda of the Oxford clay. Wm. Cunnington.

2. Hypanthocrinites of the Wenlock Shale. W. A. Lewis, B.A.

3. Tellina—Monograph continued. Fr. Edwards.

4. Brachiopoda. Th. Davidson.

5. Hordwell, fossil and geological phenomena. S. V. Wood, F.G.S., &c.

*Miscellanies*—Criticisms by the Editor. Bibliographical Notice. Clathrariophyllii, in the Kentish Rag. Lepidodendron with Stigmarian

roots. Birds versus reptiles. Mammalia, new genera, Hordwell Cliff. Bones of Loch Gur. Pentacrinus gracilis, &c. Literary Intelligence.

From the Quarterly Journal of the Geological Society, we have made frequent citations, and it is replete with valuable matter. The London Geological Journal of Mr. Charlesworth is not a rival, but pursuing an independent course avowedly without submission to the authority of names will, we trust, promote the interests of science;—the editor will avoid, as we hope, all unnecessary personalities, while he pursues fearlessly the course which truth and candor and fidelity ought to prescribe to every editor.

2. *Darlington's Agricultural Botany.*—This work is acknowledged to have been much needed. It brings science into agreeable and intelligible union with that art, in which the great proportion of our people are engaged, and which supplies a large proportion of our wants. The peculiar and important relations of botany to medicine, the vegetable kingdom furnishing perhaps two-thirds or three-fourths of the articles of the *materia medica*, have often been well and fully treated. In agriculture there is a very much closer dependence on botany. It would be a great public benefit if some patron of the useful arts would distribute Dr. Darlington's work, gratuitously, by thousands, to the farmers of the author's native state, as a certain work from over the water was distributed through an adjoining state, for the benefit of agriculture.* It should be made a class book in our schools, and children throughout this Union should be taught to rival their neighbors, in having their own regarded as the *garden* state, rather than to pride themselves on distinctions which are marks of political strife and love of power.

The work is dedicated to the young farmers of the United States, for reasons which the Preface satisfactorily explains; and we find in the same place an important suggestion, that a work expressly devoted to the *Botany* of the *Arts*, is yet to be supplied. The writer's favorite authorities are Torrey, Gray, and De Candolle. A glossary is furnished, rendering into plain English all the botanical terms used; there is also an explanation of the abbreviations and references. We have moreover in a synopsis the Linnæan arrangement of the genera treated of, followed by a summary of the groups and orders noticed in the work, after the plan of Gray: the first series, that of flowering plants, occupies in the text 236 pages, and the second, that of flowerless plants, but 10 pages. Following a scientific description of each plant, its origin, history, &c., are the author's own observations, showing its relation to agriculture.

The plants treated of are classified in tables under the following heads; which give at a glance, an idea of the particular subjects and their importance:

1. Plants yielding esculent *Roots*, *Herbage*, or *Fruits*, for *Man*.
2. Plants yielding *Food* exclusively or chiefly for *Domestic Animals*.
3. Plants yielding *Condiments* or *Drinks*.
4. *Medicinal* plants.

---

* Johnson's Agricultural Chemistry, in New York.

5. Plants employed in the *Arts*, in *Commerce*, in *Domestic* or *Rural Economy*.

6. *Pernicious* plants.

7. Plants which are *mere weeds*.

No one has devoted himself more sedulously than our author, to promote the true interests of agriculture, to inculcate a sense of the dignity and elevated character of the pursuit, and the importance of science to those engaged in it. This is proved by numerous addresses, lectures, and publications, a list of which we here annex.

1. *Address*, at the Third Annual Meeting of the Pennsylvania Agricultural Society, held at Prospect Hill, Philadelphia Co., Oct. 21, 1825.

2. *Address* to the Chester County Cabinet of Natural Science, at the organization of the Society, March 18, 1826.

3. *Florula Cestrica:* An Essay towards a Catalogue of the Phænogamous plants, native and naturalized, growing in the vicinity of the Borough of West Chester, Pa. April 28, 1826.

4. *Flora Cestrica:* An attempt to enumerate and describe the Flowering and Filicoid Plants of Chester County, Pa. April, 1837.

5. *An Essay* on the Development and Modifications of the External Organs of Plants. Compiled chiefly from the writings of Goethe. March 1, 1839.

6. *A Discourse* on the Character, Properties, and importance to Man, of the Natural Family of Plants, called Gramineæ, or True Grasses. February 19, 1841.

7. *Address* to the New Castle County Agricultural Society and Institute, at the Eighth Annual Meeting, held at Wilmington, Del., Sept. 13, 1843.

8. *A Lecture* on the Study of Botany; read before the Ladies' Botanical Society, at Wilmington, Del. March 2, 1844.

9. *Address* delivered before the Philadelphia Society for promoting Agriculture, at the Annual Axhibition, October 17, 1844.

10. *Address* before the Chester County Horticultural Society, at their First Annual Exhibition, in Westchester, Pa. Sept. 11, 1846.

11. *Agricultural Botany:* An Enumeration and Description of Useful Plants and Weeds, which merit the notice, or require the attention, of American Agriculturists. June, 1847.

12. *A Discourse upon Agriculture:* at a meeting of citizens of Oxford and vicinity, Chester County, Pa., assembled for the purpose of forming an Agricultural Society, September 4, 1847.

3. *Foraminifères fossiles du bassin tertiaire de Vienne, decrits par* Alcide D'Orbigny. 4to, with numerous plates. *Paris*, 1846.—When it was asserted, many years since, by Lamarck, that more had been contributed to the formation of the earth's crust by microscopic shells, than by whales, mammoths and hippopotami, comparatively little was known as to the real extent of the labors of the minute but beautiful beings called Foraminifera by d'Orbigny, and Polythalamia by Ehrenberg. Thanks to the labors of the eminent naturalists just named, the immense importance of these minute creatures as architects of the earth's crust is now generally known. D'Orbigny in particular has devoted almost a lifetime to their study, and until Ehrenberg investigated the still more minute forms of this class, the former naturalist was almost the only worker in this field.

To d'Orbigny we are indebted for the first scientific classification of these bodies;* for a beautiful series of plaster models of them† which have made their curious forms familiar to naturalists; and for several important memoirs, not only upon the living species,‡ but upon the peculiar forms belonging to the chalk and other strata.§

The work whose title stands at the head of this notice, is the last contribution made by this indefatigable author to his favorite department of science. It is a beautiful quarto volume, with more than 300 pages of text, and 21 elegant and well filled plates. The text is given in both the German and French languages, and the execution of the whole volume is worthy of the imperial auspices under which it was published.

The Chevalier de Hauer having made an immense collection of the Foraminifera from the tertiary deposits of Austria, prevailed upon M. d'Orbigny to undertake their scientific study, and the Emperor of Austria liberally defrayed the expense of the publication of the work, to the preparation of which the author devoted not less than two years.

This work is not one of merely local interest. No one familiar with the subject, who looks upon its plates, can fail to be struck with the resemblance which many of the forms bear to the fossils which are accumulated in such immense quantity in the tertiary beds beneath Charleston, S. C.,‖ and which are scarcely less abundant in the tertiary of Virginia.

This work on the Austrian forms will be indispensable to all who would study the species belonging to deposits of the same age in other localities. A very valuable portion of the work is an introduction giving a complete exposition of the present views of the author concerning the classification of the Foraminifera, to illustrate which, figures of every genus now known are given. Of high interest also are the author's general paleontological remarks. Commencing with the carboniferous epoch in which the first Foraminifers occur under the form of the genus Fusulina,¶ a detailed statement is given of the successive additions of genera and species during the different epochs, up to the present time. It appears from the data hitherto obtained, that the number of genera and species in the different periods was as follows:

| | | |
|---|---|---|
| Carboniferous, | 1 genus, | 1 species, |
| Jurassic, | 5 genera, | 20 " |
| Cretaceous, | 34 " | 280 " |
| Tertiary, | 56 " | 450 " |
| Recent, | 68 " | 1000 " |

It appears too, that certain genera are peculiar to certain formations, although some of those which accompanied them may also occur in

* Annales des Sciences Naturelles, Janvier, 1826.

† Complete sets are for sale at Rue Louis-le-Grand, No. 5, Paris.

‡ Foraminifères de Cuba et des Antilles, 1839.

§ Foraminifères de la Craie blanche, Mem. de la Soc. Geol. de France, 1839.

‖ Recent borings made for an Artesian well at Ft. Sumpter, in Charleston harbor, have reached the Polythalamia beds which were first detected in boring an Artesian well in the city of Charleston. An abundant supply of the marls crowded with beautiful microscopic forms in a perfect state of preservation, has been sent to us for examination, by Capt. A. H. Bowman, of the U. S. Engineers.

¶ For a notice of American Fusulina limestones, see this Journal, vol. ii, ii Ser., p. 293.

more recent deposits. The value, therefore, of these minute medals of creation in the determination of the age of strata is fully established.

Upon this point D'Orbigny remarks, "that after having devoted twenty years to the study of the Foraminifers he has become fully convinced that they can in all cases be used to determine with certainty the age of a geological formation, if in their comparison there is used that precision of observation which is indispensable to every conscientious labor in zoology or comparative anatomy." Even where it may be the easiest method to determine the age of a stratum by means of the mollusks and other large fossils which it may contain, the accompanying microscopic forms, which in general are far more numerous, should not be neglected. The business of the geologist is not merely to identify strata, but to give a comprehensive and philosophical view of all the phenomena of the epoch under examination, and surely none can be more wonderful than those connected with the labors of those Lilliputian chemists, who little by little have separated from the ocean waters, organized masses of carbonate of lime or silica, which play no inconsiderable part in the formation of our present continents.

In our American strata the Foraminifera are very abundant; the borings of every Artesian well made through the cretaceous or tertiary strata of the southern states, afford a rich supply of these elegant forms. Beautiful living species occur along our coast, but are rare along our sandy shores, in comparison with the immense profusion in which they occur near the Gulf Stream. From a recent examination of soundings taken at depths of about 100 fathoms and at various points near the Gulf Stream,* it appears that the Foraminifers form along the course of this ocean current a perfect milky-way of organic life, whose nebulæ however are easily resolved by the microscope.

While we close this article by recommending the various works by M. d'Orbigny as indispensable to all who would pursue this branch of microscopic paleontology, we would also invite attention to an interesting memoir by Dr. Mantell, on the Fossil Remains of the soft parts of Foraminifera in English Chalk and Flint,† and to another by W. C. Williamson, Esq., on some of the Microscopical Objects found in the Mud of the Levant.‡ Both of these memoirs are valuable contributions to our knowledge of the minute workers in lime and silica, and other vast additions may be hoped for in Ehrenberg's long expected volume, which is to give the results of his comparison of the microscopic beings, recent and fossil of all parts of the world. J. W. B.

4. *Lexicon Scientiarum—a Dictionary of Terms used in the various branches of Anatomy, Astronomy, Botany, Geology, Geometry, Hygiene, Mineralogy, Natural Philosophy, Physiology, Zoology, &c.*, for the use of all who read or study in College, School, or Private Life. By HENRY MCMURTRIE, M.D., &c., Prof. of Anatomy, Physiology and

* For these soundings we are indebted to A. D. Bache, Esq., Superintendant of the U. S. Coast survey. The soundings abound in many new and interesting organic forms, a memoir upon which is now in the course of preparation.

† Phil. Trans., Part IV. 1846.

‡ On some of the Microscopic Objects in the Mud of the Levant, and other deposits, with remarks on the mode of formation of Calcareous and Infusorial Siliceous Rocks, by Wm. C. Williamson, Esq. Manchester, 1847.

Natural History in the Central High School of Philadelphia. E. C. & I. Biddle, 1847: Philadelphia.

The author was induced to compile this work on account of the difficulties which he experienced as a teacher.

His plan is intended to include "the terms usually employed in all the sciences, to the utter exclusion of ordinary words." Thus he has been able to construct a small portable and cheap book, and to avoid the reproach of his own motto—*μεγα βιβλιον μεγα κακον.*

The etymology of the words is given, and essentially aids the memory. The book is handsomely printed, with a good paper and type—the principal words in capitals, and the explantions in a clear readable character—forming a pocket volume of about 250 pages.

As far as we have looked into it, the definitions appear to be correct, concise and perspicuous, and we believe the work will prove a very useful auxiliary to the student of the natural sciences.

5. *Outlines of the Course of Qualitative Analysis followed in the Giessen Laboratory.* By HENRY WILL, Ph. D., with a preface by Baron LIEBIG. Boston: James Monroe & Co., Sept. 1847. 12mo, 145.—All who are engaged either in teaching or acquiring the difficult art of chemical analysis, will feel grateful for this brief but important manual. Baron Liebig says, "The want of an introduction to chemical analysis, adapted for the use of a laboratory, has given rise to the present work, which contains an accurate description of the course I have followed in my laboratory with great advantage for twenty-five years. It has been prepared at my request by Prof. Will, who has been my assistant during a great part of this period." This work has been adopted in the analytical laboratories both in Cambridge and New Haven.

C. D. BADHAM: A Treatise on the Esculent Funguses of England, *London*, 8vo, 1847.

T. & J. AUSTIN: Monograph on Recent and Fossil Crinoidea, No. 6, 4to, *London*. "About 20 numbers (3*s*. 6*d*. each) will complete the work."

P. H. BOUTIGNY: Nouvelle Branche de Physique, ou études sur les corps à l'etat sphéroidal. 8vo, 2d edit., *Paris*, 1847.

JAMES T. HODGE: Report of a Tour of Exploration through the Mineral Locations of Montreal River, Lake Superior. 1847, 19 pp. 8vo, with a map.

J. J. BERZELIUS: Neues Chemisches Mineralsystem; herausgegeben von C. F. Rammelsberg. 264 pp. 8vo. *Nürnberg*, 1847.

PROCEEDINGS OF THE AMER. ACAD. OF ARTS AND SCIENCES, BOSTON.—p. 50. *Jan.*, Observations on the planet Neptune; *W. C. Bond.*—*Feb.*, p. 51. On the Chinese Language; *S. P. Andrews.*—*March*, p. 57. Correspondence of a star observed by Lalande with the planet Neptune; *J. C. Walker.*—On the comet of March 4, 1847; *W. C. Bond.*—p. 71. Series of moon culminations observed at the Cambridge Observatory; *W. C. Bond.*—p. 104. Series of moon culminations observed at Dorchester; *W. C. Bond.*—*April*, p. 129. Demonstrations relating to rectilineal triangles; *Prof. T. Strong.*—*May*, p. 144. On the planet Neptune; *Prof. Peirce.*—p. 149. Conspectus of Crustacea of the Exploring Expedition under C. Wilkes, U.S.N.; *James D. Dana*, (includes species of the genera Cyclops, Harpacticus, and the two new genera Clytemnestra and Setella.)—p. 158. Meteorological register kept at the Bay of Islands, New Zealand; *J. B. Williams.*

PROCEEDINGS OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA.—*July*, p. 229. Observations on certain coal fossils from Cape Breton, Nova Scotia; *R. Brown, Esq.*—p. 233. Description of a new *Columba* (C. solitaria) from Mexico,* and remarks on the Geococcyx viaticus; *G. A. M'Call.*—*August*, p. 248.

* See this volume, page 421.

Description and Anatomy of a new subgenus of Planaria; *J. Leidy.*—p. 251. Descriptions of two new species of Planaria; *J. Leidy.*

Annals and Magazine of Natural History, Vol. xx, No. 131. *August.* On the Ventriculidæ of the Chalk; *J. T. Smith.*—Geographical Distribution and Classification of Zoophytes; *J. D. Dana.*—Circulation in Insects; *E. Blanchard.*—Microscopic silicious Polycistina of Barbadoes; *R. H. Schomburgk.*—*Lit. and Phil. Soc. of St. Andrews:* Dr. Reid on the development of the Medusa.—*Zoological Society:* J. E. Gray on the genera of the family Chitonidæ.

No. 132. *September.* Fossil Botany and Zoology of the coal formation of Australia; *F. M'Coy.*—Note on the Teredo Norvegica, Xylophaga dorsalis, Limnoria terebrans and Chelura terebrans; *W. Thompson.*—On the pliocene deposits of the valley of the Thames at Ilford; *R. P. Cotton.*—Additions to the Fauna of Ireland; *W. Thompson.*—On the Ventriculidæ of the Chalk; *J. T. Smith.*—*Zoological Society:* Dr. Davy on the early generative power of the Goat; J. E. Gray on some new genera and species of Asteriadæ; A. Adams on a new species of Fulgora; A. White on some new Crustacea in the British Museum; G. B. Sowerby on several new species of Spondylus.

Bulletin (Monatsbericht) of the Royal Prussian Academy, Berlin. *October*, 1846. On the new planet; *Encke.*—On the anomalous form of the annual temperature curve in North America; *Dove.*—On the larva condition and the metamorphosis of the Ophiura and Echinus; *Muller.*—*November.* On the Carburets of Iron; *Karsten.*—Microscopic investigation of the Sirocco dust; *Ehrenberg.*—On the decomposition of water by Galvanism, and some allied topics; *Poggendorff.* On heat; *H. Knoblauch.*—On the position of the Cycadeæ in the Natural System; *Link.*—*December.* On microscopic organisms from the volcanic ejections of Iceland; and also from a new case of Sirocco dust, from Genoa, May 16; *Ehrenberg.*—Microscopic Polycistina from Barbadoes; *Ehrenberg.*—*January*, 1847. Reaction of metallic zinc with mercurial solutions; *H. Rose.*—On promoting the decomposition of water by galvanism; *Poggendorff.*—On the geographical distribution of the Camel and Date Palm; *Ritter.*—On the deposit of stone salt at Stafsfurth, and on the Boracite in salt beds; *Karsten.*—On the planet Astræa; *Encke.*—*February.* On the movement of heat in the earth's strata of different geognostic character; *Dove.*—A new insectivorous mammal, genus Rhyncocyon, from Mozambique (R. Cirnei); *Peters.*—Chemical investigation of silicates containing chlorine, sulphuric acid and carbonic acid; *Whitney.*—Microscopic siliceous Polycistina from Barbadoes, &c.; *Ehrenberg.*—Discovery of Creatine in Urine; *Heintz.*—Examination of the ashes of organic substances; *H. Rose.*—On the appearances presented by polarized light, when the plane of polarization is suddenly turned; *Dove.*

Bulletin de la Société Impériale des Naturalistes de Moscou. Année, 1846. 3 pl.—No. I. Observations on Scandinavian Geology; *E. Eichwald.*—Coleoptera Myrmecophila fennica; *F. G. Mæklin.*—Hylæus quadricinctus, Fabr.; *E. Eversmann.*—No. II. A systematic arrangement and economical review of grape vines; *Dr. F. A. Kolenati.*—Remarks on the collection of Russian Coleoptera of Victor de Motschoulsky.—Treatise on the atomic theory; *P. Einbrodt.*—New or little known species of Russian Coleoptera; *Dr. E. Eversmann.*—Geological section of the environs of Moscow; *M. Rouillier.*—Notes upon some passages of the work of Murchison, Verneuil and Keyserling, on the Geology of Russia and the Urals; *J. Auerbach* and *H. Frears.*—On the beetles of the Aleutian Islands and Sitka; *C. G. Mannerheim.*—Supplement to a memoir on the foliaceous Musci of the Russian empire; *A. Weinmann.*—Meteorological observations made at the astronomical observatory of the Imperial University of Moscow; *Spassky.*

Index photographed at the
beginning for the convenience
of the microfilm user.